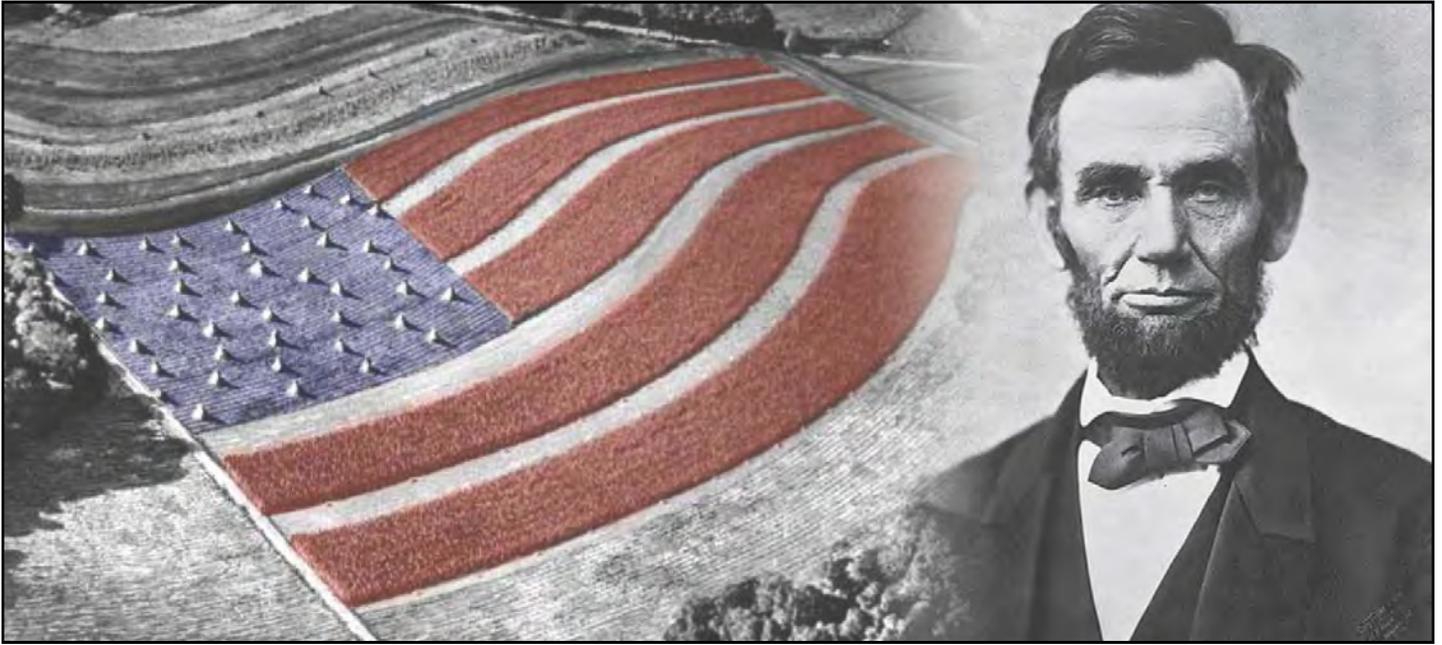




**FY2015 U.S. Department of Agriculture  
Annual Report on Technology Transfer:  
Agricultural Research Service Section**



*Celebrating over 150 years of research for a growing world.*

### 3.0 Agricultural Research Service (ARS)

<http://www.ars.usda.gov>

#### 3.1. Mission Statement

ARS conducts research to develop and transfer solutions to agricultural problems of high national priority and provides information access and dissemination to:

- ensure high-quality, safe food, and other agricultural products;
- assess the nutritional needs of Americans;
- sustain a competitive agricultural economy;
- enhance U.S. natural resources and the environment; and
- provide economic opportunities for rural citizens, communities, and society as a whole.

#### 3.2. Nature and Structure of Research Program

ARS is USDA's principal intramural scientific research agency. Agency goals are to find solutions to agricultural problems that affect Americans every day, from field to table, such as (a) protecting crops and livestock from pests and diseases, (b) improving the quality and safety of agricultural products, (c) determining the best nutrition for people from infancy to old age, (d) sustaining our soil and other natural resources, (e) ensuring profitability for farmers and processors, (f) keeping costs down for consumers, and (g) supporting the growth and development of Rural America.

ARS employs approximately 2000 scientists and post docs, as well as, approximately 6,000 other employees to conduct 750 research projects at over 90 locations. The research projects are within 17 National Programs (Table 1). The Office of National Programs in Beltsville, MD plans the scope and objectives of Agency's research projects, while five Area Directors implement research projects at the locations in their geographic areas.

**Table 1. Research program management of ARS, showing 17 National Programs.**

Animal Production & Protection	Natural Resources & Sustainable Ag Systems	Crop Production & Protection	Nutrition, Food Safety & Quality
Food Animal Production	Water Availability & Watershed Management	Plant Genetic Resources, Genomics & Genetic Improvement	Human Nutrition
Animal Health	Climate Change, Soils, and Emissions	Crop Production	Food Safety
Veterinary, Medical, & Urban Entomology	Pasture, Forage & Range Land Systems	Plant Diseases	Quality and Utilization of Agricultural Products
Aquaculture	Biorefining	Crop Protection & Quarantine	
	Agricultural & Industrial Byproduct		
	Agricultural System Competitiveness & Sustainability		

ARS conducts a series of reviews designed to ensure the relevance and quality of its research work and maintain the highest possible standards for its scientists. Customer input helps keep the research focused on the needs of the American food and agricultural system. Plans for each of the active research projects undergo a thorough independent external prospective peer review managed by the Office of Scientific Quality Review (OSQR). All ARS employees, including the scientific workforce, are subject to annual performance reviews, and all research scientists and engineers have technology transfer as a performance element in their annual performance appraisal. Research scientists undergo a rigorous peer review (Research Position Evaluation System-RPES) on a 3 to 5-year cycle. These processes ensure the continuing high quality output of the ARS research addressing the needs of U.S. agriculture.

### **3.3. ARS Approach and Plans for Conducting Technology Transfer**

Because of the delegations of authority by the Secretary, ARS's Office of Technology Transfer (OTT) is assigned the responsibility for obtaining patent protection for intellectual property (IP), developing strategic partnerships with outside organizations, licensing ARS technologies to the private sector and academia, and performing other activities that effectively transfer ARS research outcomes and technologies to the marketplace. USDA's Office of the General Counsel provides legal guidance to OTT in regard to intellectual property as needed.

The ARS technology transfer program has centralized policy and approval procedures that are managed by OTT. Research agreement negotiation and implementation is decentralized and managed by the ARS Area Offices. The Area Office Technology Transfer Staff serve as liaisons with scientists, ARS managers, OTT, university partners, and the private sector.

To facilitate technology transfer, OTT is organized into three sections. The *Administrative and Partnership Section* conducts day-to-day operations, coordinates technology transfer policy development, interacts with the Office of National Programs on agreement policy and review, and coordinates the activities between the partnership, patenting, and licensing sections. This Section maintains strong stakeholder relationships at the local, regional, and national levels, ensuring the adoption of research results. This Section is also responsible for coordinating and managing both agreements and the Agricultural Research Partnerships (ARP) Network. The *Patenting Section* provides strategic guidance to scientists regarding patent protection for their research results. The Section is also responsible for receiving invention reports, convening three National Patent Committees (Mechanical and Measurement, Life Sciences, and Chemistry), preparing and prosecuting patent applications, and reviewing patent legal work performed by cooperator and ARS contract law firm. The *Licensing Section* manages invention licensing from all the intramural scientists in every USDA agency, including the review of license applications and the negotiation and monitoring of license agreements to assure compliance with agreement terms. This Section also collects and disburses license revenues, manages international patent filings, and provides expert advice on all matters related to USDA invention licensing.

Technology transfer is accomplished through many mechanisms, such as:

- developing written information for customers and stakeholders, including scientific publications, publications in trade journals, and reports to stakeholders;
- releasing plant germplasm to the public;
- transferring research materials to scientists outside of ARS;
- entering into formal partnership agreements, such as CRADAs, and other cooperative agreements;
- licensing IP (patents, Plant Variety Protections Certificates, and biological materials);
- participation in meetings with industry organizations and universities, workshops and field days; and distributing information to the public via the ARS Information Staff, the National Agricultural Library, and other sources.

Because the ARS mission is to transfer technologies for broad public use by the most effective mechanism, ARS pursues patents and licensing principally when they facilitate technology transfer to the marketplace. This is usually the case when complementary investment by the private sector is necessary to commercialize a product, and patent protection is required to protect this investment. By ARS policy, patents are not filed on inventions that are considered to be only research tools. The purpose of this policy is to encourage scientific research. In licensing practices, ARS continues to reserve the right to allow use of any IP protected technology for research purposes (non-commercial). Judicious use of intellectual property rights (IPR) is an important cornerstone of the patent committees. IPR is used as an incentive for commercialization and full realization of the research impact of USDA technologies.

Meaningful performance metrics in technology transfer are often difficult for research agencies to formulate. ARS is continuing to work on defining better metrics for technology transfer within USDA. For example, for ARS, successful outcomes may include improved agricultural practices, scientific information that enhances U.S. competitiveness, increased awareness about pathogens to help prevent human and animal diseases, or findings that help corporations and universities make informed decisions in allocating their research resources. Many of these outcomes do not require patenting or subsequent licensing for implementation. Additionally, ARS uses its ARP Network to match technical expertise of ARS researchers with firms who can capitalize on the ARS research capacities, facilities and research outcomes.

Licensing policies also promote small business success with licensing fees in the early years, but with annual maintenance fees and royalties that escalate in subsequent years, sometimes after the first commercial sale of the product. Licensing further enhances commercialization by encouraging broadest utilization of a federal invention. ARS also incentivizes scientists on the reporting of inventions, patenting, and licensing by providing 25% of the license revenues to inventors (this is a higher percentage than that required by statute,  $\geq 15\%$ ). Thus, there are policies in place that incentivize commercialization, minimize transaction costs, and yet provide fair and equitable compensation for those who create federal innovations. Development and expansion of the ARP Network further enhances the adoption of research outcomes.

These are all parts of a robust and effective technology transfer program that consists of a variety of mechanisms and programs to complement the research conducted by the agencies.

### **3.4. Agricultural Research Partnerships (ARP) Network Program**

ARS founded the ARP Network in an effort to expand the impact of ARS research by enhancing the likelihood that these outcomes are adopted. Although replete with scientific expertise, the ARS research program does not have the resources or the authority to provide ARS commercial partners with business mentoring, marketing, manufacturing, and fiscal resources needed for the success of their businesses. Consequently, the Network was established to provide these complementary assets. By combining ARS research expertise with complementary capabilities and talents of partnering organizations, the ARP Network helps stimulate economic growth through technological advancements. The ARP Network matches business needs with ARS innovations and research capabilities and provides business assistant services to help companies and startups solve agricultural problems, develop products and create new jobs.

The ARP Network includes the important parties in an innovation ecosystem and has members spanning the U.S. with a shared vision to grow and sustain a competitive agricultural economy. Members include ARS and stakeholders interested in agriculture-based economic development including, but not limited to rural agribusiness; urban, community and/or economic development groups; organizations that support farmers, growers and/or food processors; and capital programs for business attraction and acceleration. Membership in the ARP Network is formalized through Non-Funded Cooperative Agreements.

### **3.5. Agricultural Technology Innovation Partnership (ATIP) Foundation**

The nine founding members of the ARP Network established the ATIP Foundation in 2011 to provide a unifying entity independent of ARS with the flexibility to engage other organizations that have a vested interest in seeing USDA research outcomes adopted by the private sector (<http://atipfoundation.com>). Foundation objectives are: (1) Expedite the transition of USDA technologies from USDA labs into the commercial sector; (2) Increase the use of agriculture technology discoveries that meet the needs of emerging markets (3) Seek funding to support the technology needs of the Agricultural industry and efforts to adopt and commercialize new technologies; (4) Develop industry access to utilize USDA research and research facilities; (5) Create sustainable communities by promoting regional innovation clusters, supported by USDA research outcomes; (6) Co-host regional events with USDA, showcasing technologies and facilitating adoption of research outcomes; and (7) provide for the development of skilled workers needed to sustain the growth of the industry.

The Foundation's interface with the USDA is through the USDA Liaison Committee (LC). The LC is an internal USDA committee and not a part of the Foundation. The LC serves three primary purposes: (1) to ensure the independence of USDA-ARS research activities; (2) maintain mission relevance; and (3) align the purpose of research and mission with the work of the ATIP Foundation. The USDA Liaison Committee will receive and the USDA Liaison Committee will review and approve internal USDA and external Foundation requests to fund USDA research to determine whether those requests fit the USDA mission and research priorities.

The ATIP Foundation established two Public-Private Partnerships with ARS: *Resilient Economic Agricultural Practices* and *Branded Food Products Database for Public Health Public-Private Partnership*.

### **Resilient Economic Agricultural Practices Public-Private Partnership**

This project was initially funded through a federal grant and expired in FY2013. At the request of ARS, a new funding mechanism was established by the ATIP Foundation to ensure uninterrupted continuation of this project in data collection and development of guidelines and tools needed to assess long-term effects of food, animal feed, fiber, and biofuels production on soil health. The new public-private partnership capitalizes on federal scientific research on soil health through cost sharing with private sector firms and organizations that have an interest in continuation of this research. Through this public-private partnership, funds are available for on-going research at university and ARS locations in Ames, IA; Morris, MN; St. Paul, MN; Lincoln, NE; Brookings, SD; University Park, PA; Akron, CO; and Florence, SC. The REAPnet database was developed which was closely aligned with the ARS Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network (GRACENet) database. The database application is a data discovery tool that provides site-specific projects information that, once peer-reviewed, will become publically available.

At November 2014 Tri-Society (American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America) Annual Meeting in Long Beach, CA, REAP scientists reported results of multi-location studies that included a 239 site-year yield dataset. In addition, a broad range of environmental issues (e.g., soil organic carbon, microbial communities, cover crops, etc.) related to corn stover management was discussed.

### **Branded Food Products Database for Public Health Public-Private Partnership Accomplishments**

In FY 2013, ARS, the ATIP Foundation, and the International Life Science Institute North America (ILSI North America) established a public-private partnership to enhance the public's health through increased knowledge of the nutritional content of the nation's food supply. This will be accomplished by obtaining comprehensive food composition data from the food industry and making it available to government, industry, the scientific community and the general public through an enhanced USDA National Nutrient Database, developed and maintained by the ARS Nutrient Data Laboratory in Beltsville, MD.

In FY2015, the public-private partnership successfully beta tested a branded food products database. Five food

manufacturers participated in a beta-test by providing product label data and nutrition information on 245 products through a GS1 certified data pool provider, FSEnet. These data were then passed to ARS for incorporation into the USDA National Nutrient Database.

### 3.6. Technology Transfer Highlights

- 59 new CRADAs were executed and the scope of research was expanded through amending 76 active CRADAs. The current 211 active CRADAs are valued at more than \$113,074,045 over the course of their life (up to 5 years) with more than \$24,982,824 in funds going directly to ARS researcher projects. Approximately 53% percent of the newly executed CRADAs were with small businesses. A new type of research agreement (Material Transfer Research Agreement, MTRA) was developed in FY2013 to fit the needs of specific research projects (refer to President Initiative USDA 13). Some collaborators that would have entered into a CRADA prior to the advent of this new agreement, now may find an equally viable option in entering into and MTRA. There were 102 new MTRAs. Refer to Table 1 in Section 3.8 and figures 1, 2 and 3 in Section 3.12.
- 193 invention disclosures were received; 110 patent applications were filed; and 84 patents and PVP certificates were obtained. There was 90% increase over last year in the number of invention disclosures. Judicious use of intellectual property rights (IPR) is an important cornerstone of the patent committees. IPR is used as an incentive for commercialization and full realization of the research impact of USDA technologies. While the year in which a patent issues is the not the year in which the patent is filed, over time the ratio of the number of patent application filed over the number of patents issued does represent a trend of the percentage of patents that are issued. Refer to Table 2 in Section 3.8 and Figures 4, 5 and 6 in Section 3.12.
- 35 new licenses were executed. This was an increase of ~20% over last year. Of the new licenses agreements that were executed, 46% were with small businesses and 26% with universities. The number of income bearing licenses, as well as the earned royalty income, has steadily increased over the last five years. The total royalty income (\$5,066,988) was the highest in the last 5 years. 68% of the active licenses were granted exclusively. Most of the \$3,509,904 in earned royalty income (ERI) came from a few licenses, for the median ERI was \$3,525. In addition to the new licenses, 5 license amendments were executed. Refer to Tables 3, 4 and 5 in Section 3.8 Figure 7, 8 and 9 in Section 3.12.
- Developed and implemented the first edition of the ARP Network Newsletter highlighting CRADA and licensing opportunities and other information. In addition, participated in ARP Network members' events in Colorado, Oklahoma, and Connecticut. Connected 33 companies with ARS researchers and directly marketed 37 technologies for licensing using the ARP Network and other venues.
- In FY2015, USDA-ARS laboratories won 6 Federal Laboratory Consortium (FLC) National Excellence in Technology Transfer awards and 11 FLC Regional Excellence in Technology Transfer awards. Refer to Section 3.11.
- To further improve the changes that research outcomes will be adopted, a technology transfer strategy session was implemented in FY2015 for each of the inventions reviewed by the patent committee. After the patent committee, a conference call for each invention disclosure is held with the researcher, Patent Advisor, Licensing Specialist, and Technology Transfer Coordinator to discuss the strategy for moving forward. If the decision was not to pursue patent protection, the discussion focused on what other mechanisms could be used to get the research results adopted (i.e., trade journal article, workshops, etc.) or what other data was needed (i.e., research partnerships). If the decision was to pursue patent protection for the invention, the discussion

focused on what claims are needed in the patent application to get the widest adoption and the ensuing licensing strategy (i.e., exclusive license needed, targeted market sector, etc.).

- Held a technology transfer workshop with the field technology transfer professionals. Some of the outcomes of the workshop included: 1) a plan for increasing the number of invention disclosures by harvesting inventions from manuscripts submitted for publication; In FY2015, 25 invention disclosures were submitted after reviewing manuscripts; 2) a plan for training researchers on developing technology transfer strategies for their research outcomes before the research is completed through uniform AgLearn e-learning and site visits by field technology transfer professionals and OTT-HQ staff. In FY 2015, OTT-HQ visited three field locations for training; and 3) a plan for targeted marketing new technologies once a patent application has been filed through the ARP Network. In FY2015, 37 technologies were marketed through the ARP Network.
- The OTT website (<http://www.ars.usda.gov/Business>) was updated with more content and information. Some of the new additions include information on the use of the ARS Utilization Centers for the commercial scale-up of lab methods; patents applications filed and patents issued; informational videos; new technology transfer PowerPoint training series; new updated agreement templates; redesign of licensing page; additional items in the news and events paper; and updated list of available technologies for licensing. USDA facilities and available technologies were also submitted to data.gov
- For the National 75th Anniversary celebration for the four USDA Utilization Centers, OTT developed a document listing each of the pilot plant's specialized facilities and research expertise for the commercial scale-up of laboratory-level technologies, as well as past accomplishments. This information was developed into a series of uniform posters that have been placed on the OTT website (<http://www.ars.usda.gov/business/Docs.htm?docid=25285>). In FY2016, a webinar will be held through the ARP Network to make industry aware of these unique facilities.
- An SBIR-Technology Transfer Program, a new collaboration between the USDA's National Institute of Food and Agriculture (NIFA) Small Business Innovation Research Program (SBIR) and ARS, was established in FY 2014. This program encourages SBIR applicants to work with ARS researchers and/or license ARS technologies. The relevant language in the SBIR Request for Applications states: "Additional factors that will be considered in the review process include whether an application involves a CRADA with a USDA laboratory, or a license to a USDA technology...A list of available technologies for licensing and CRADAs that may be considered as projects under the SBIR program can be found at the USDA Office of Technology Transfer (OTT) website." In FY 2015, four CRADA projects were submitted for SBIR funding, three of which were awarded. Typically, 10-15% of USDA-SBIR proposals are funded. The higher success rate of CRADA-SBIR proposals (~75%) is likely due to the ARS selection process in identifying and research plan review process for solving agricultural problems of high national priority.
- OTT piloted a NSF I-Corps™ program for USDA-ARS. The ARS Innovation Corps (I-Corps@ARS) pilot was a set of activities and programs that prepared ARS scientists to extend their focus beyond the laboratory and broadened the impact of select ARS research projects. Combining experience and guidance from established entrepreneurs with a targeted curriculum, NSF I-Corps™, on which I-Corps@ARS was based, taught the teams to identify the real problems facing stakeholders and to develop valuable products and/or market opportunities that can emerge from their own research. In addition, I-Corps ARS offered entrepreneurship training which helped the participants to be more innovative and impactful in their research programs. Each USDA-ARS team was composed of one scientist, one post-doctoral fellow and one technology transfer professional. This model was an adaptation of NSF I-Corps for participation of intramural scientists.
- OTT represented USDA in the USPTO-Smithsonian 2015 Innovation Festival. The Innovation Festival is a family oriented, educational opportunity for the public, to meet and interact with innovative corporations,

academic institutions, federal government agencies, and independent inventors from across the nation. The Festival features breakthrough patented American technology. At this year's Festival, OTT highlighted the breeding research that resulted in patented and licensed ornamental-culinary pepper cultivars. This year's Festival was held at the National Museum of American History with an estimated attendance of over 30,000.

- OTT professional staff played a very active role in the Federal Laboratory Consortium both at the national and regional levels (e.g. coordinator of the Mid-Atlantic region, member of the national executive board, trainers, tech transfer award reviewers, and meeting speakers). This collective effort of ARS technology transfer professionals was recognized in FY2015 with a Silver President's Volunteer Service Award.
- OTT took the lead in planning and holding a Forum on Mapping, Satellite and Sensor Technologies for the Mid-Atlantic region. The Forum highlighted on-going research and commercial opportunities from seven Federal agencies (U.S. National Geospatial-Intelligence Agency, National Oceanic and Atmospheric Administration, U.S. Department of Agriculture, U.S. Geological Survey, National Institute of Standards and Technology, U.S. Naval Research Laboratory, and National Aeronautics and Space Administration) and three universities (University of Maryland, Washington College, and Salisbury University). Topics included: 1) Impact of climate change on the coastal environment; 2) Sustainable urban, agriculture, and natural environments; 3) Measurements, standards and analysis; and 4) Technology applications. The Forum drew some 85 participants. Currently, new research collaborations among the different Federal labs and universities are being created. A second Forum is being planned for FY2016 to identify commercial partners for outcomes of this new research collaborations. The goal of the Forums are to more effectively leverage Federal and university research activities for commercialization.
- OTT represented the Department for the White House Office of Science and Technology Policy's Lab-to-Market, Maker Faire and Intellectual Property Enforcement Committees.
- OTT participated in Inter-agency Working Group on Technology Transfer.
- OTT staff served as reviewers and judges for Invest Maryland Challenge, i6 Challenge (a Dept. of Commerce Grant Program), University of Maryland Technology/Invention of the Year, Maryland Economic Development Association, Patents for Humanity (run by the USPTO) and Tibbetts Awards (SBA).

### **3.7. Response to Presidential Memorandum on Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Business**

In the USDA's implementation plan for the Presidential Memorandum, ARS described 13 initiatives to promote technology transfer and commercialization. These initiatives and their implementation are described below. The following initiatives were completed in: FY 2013: USDA 1, USDA 8, USDA 9, and USDA 13; FY 2014: USDA 3, USDA 12; and FY 2015: USDA 2, USDA 4, USDA 5, USDA 7, USDA 8, USDA 9, and USDA 10.

#### **USDA 1: New metrics proposed for standard annual reporting in addition to those required by Circular A-11 instructions on annual reporting of technology transfer**

This initiative was completed in FY2013 and the new metrics are now a standard component of the metric tables.

#### **USDA 2: Update Policy and Procedure (P&P) 141.2 "Technology Transfer in ARS"**

An update is necessary to reflect statutory changes since 2000, and to reflect changes in structure and operation of the National Patent Committees, and to include licensing of biological materials and use of the ARP network. A Technology Transfer Process Working Group with representatives from the core functions involved in the

technology transfer process was established. As a result of this group, changes were made in the invention disclosure review process, as well as the development of an outline for determining a strategic and tactic technology transfer plans for research projects. Based upon these changes, a new P&P was written in FY 2015 and presently going through the approval process.

**USDA 3: Expand Agricultural Research Partnership (ARP) Network efforts to extend the impact of ARS research**

The ATIP Network was redesigned and renamed the Agricultural Research Partnerships (ARP) Network. The mission of the new ARP Network is to extend the impact of ARS research by supporting a sustainable and competitive agricultural economy. To further this mission, the ARP Network will assist ARS in creating new partnerships and in supporting existing partnerships to advance ARS research and development (R&D) and subsequent utilization, including commercialization. This expanded mission required a broader membership base. The membership base was increased to include any organization interested in agriculture-based economic development. The ARP Network includes all players in an innovation ecosystem and has members spanning the U.S. with a shared vision to grow and sustain a competitive agricultural economy. Members include ARS and stakeholders interested in agriculture-based economic development such as, but not limited rural agribusiness; urban, community and/or economic development groups; organizations that support farmers, agritourism and/or food processors; and capital programs for business attraction and acceleration. Membership in the ARP Network is formalized through non-funded Trust agreements executed by the Office of Technology Transfer. There are currently 33 ARP Network members. This new network has a web formation in that not only all the members are connected to ARS, but they can connect to each other. We will continue to add members as appropriate.

**USDA 4: Expand outreach efforts in technology transfer to scientists in ARS**

OTT worked with Office of National Programs to connect ARS scientists' research capabilities and technologies with a number of different companies. This was done through the ARP Network, responding to public solicitations, responding to industry scouting, and through webinars conducted by Federal Laboratory Consortium. This outreach effort is now an ongoing activity in OTT.

OTT began in FY 2014 the development of standard technology transfer PowerPoint training modules for ARS employees. In FY 2015, the modules were completed (Tech Transfer: Introduction, Tech Transfer: Agreements, Tech Transfer: Patenting and Tech Transfer: Licensing). The PowerPoint modules were converted and posted onto AgLearn for e-training.

**USDA 5: Encourage other S&T agencies to adopt OTT's approach to technology transfer**

In the past, OTT has provided technology transfer services (policy advice, agreement review, patenting / licensing services, etc.) to the USDA-Animal and Plant Health Inspection Service (APHIS) Wildlife Services, USDA Forest Service (FS), Department of Interior's Bureau of Reclamation (BoR). In FY 2015, these services were expanded through interagency agreements to include APHIS's Wildlife Services, Plant Protection and Quarantine, and Veterinary Services), as well as the FS's Forest Products Laboratory. In addition, the BoR agreement was modified to include the Department of Interior's (DoI) U.S. Fish and Wildlife Service.

USDA has a role in helping to develop Federal government technology transfer policy through OTT's active participation on the Interagency Working Group on Technology Transfer and the White House to Lab-to-Market Working Group. Through these ongoing activities, OTT is taking an active role in promoting activities which support the enhanced adoption of research outcomes.

**USDA 6: Explore expanded use of Enhanced Use Lease (EUL) authority as technology transfer tool to promote longer term relationships with key customer groups**

Under the 2008 Farm Bill, the Secretary was given the authority to establish a pilot project at the Beltsville Agricultural Research Center (BARC) to lease non-excess property to any private or public entities. The EUL Project was used as a technology transfer tool designed to provide longer term public-private partnerships than can be done through existing technology transfer partnership instruments. The pilot authority was used to develop a process to identify underutilized laboratory resources that could be used by the private sector to commercialize ARS research outcomes. Prospective lessees needed to establish either a licensing partnership or research collaboration with ARS. In exchange, EUL terms provide the lessee 20 years of use of the facility to develop its business. EUL authority proved to be a very successful strategy to leverage resources for entrepreneurial activities. USDA's first lessee (Plant Sensory Systems) was a small business that in FY 2013 was awarded a \$1.8 million ARPA-E grant (Better Biofuel Feedstock from Beets) based on the success of the research project conducted using BARC laboratory facilities. Access to these facilities was essential, because this small business did not have sufficient capital to build the facilities needed for this research project.

This pilot authority for BARC was reauthorized in 2014 Farm Bill. Discussion began in FY2015 to identify a partner to establish an accelerator on the BARC campus for agriculture businesses that utilize ARS technologies and/or research expertise.

**USDA 7: Beginning in FY 2012 / 2013, roll out a nationwide series of regional forums to identify issues and deliver solutions**

The goal of the regional forums is to provide technology-based solutions to regional agricultural problems for farmers and businesses. A multistep approach was developed for the regional forums: (1) a series of regional listening sessions comprised of businessmen, farmers, economic development organizations, regulatory and extension personnel are held to identify a broad list of regional issues; (2) from the list of issues, those with an existing research-based solution, or a researchable issues that could be addressed by ARS, local universities, cooperative extension, state agencies or agricultural businesses are selected as potential topics for a forum; and (3) finally, a forum is convened as a roundtable discussion on the potential solution(s) and their implementation. Participants in the forum may include farmers, growers, agri-business professionals, university and ARS researchers, extension service personnel, rural development personnel, NIST Regional Manufacturing Extension Partnership (MEP) staff, funding and regulatory agency personnel, as well as ARS technology transfers professionals. Holding regional listening session – forums is now an ongoing activity in OTT. In addition, the listening session – forum approach has been implemented within Mid-Atlantic region of the Federal Laboratory Consortium.

**USDA 8: Provide opportunities for applicants to the USDA Small Business Innovation Research (SBIR) program to partner with ARS scientists to further develop science necessary for business success**

An SBIR-Technology Transfer Program, a new collaboration between the USDA's National Institute of Food and Agriculture (NIFA) Small Business Innovation Research Program (SBIR) and ARS, was established in FY 2014. This program encourages SBIR applicants to work with ARS researchers and/or license ARS technologies. The relevant language in the SBIR Request for Applications states: "Additional factors that will be considered in the review process include whether an application involves a CRADA with a USDA laboratory, or a license to a USDA technology... A list of available technologies for licensing and CRADAs that may be considered as projects under the SBIR program can be found at the USDA Office of Technology Transfer (OTT) website." This program is now an ongoing activity of OTT and NIFA." In FY 2015, four CRADA projects were submitted for SBIR funding, three of which were awarded. Typically, 10-15% of USDA-SBIR proposals are funded. The higher success rate of CRADA-SBIR proposals (~75%) is likely due to the ARS selection process in identifying and research plan review process for solving agricultural problems of high national priority.

**USDA 9: Provide Cooperative Research and Development Agreement (CRADA) partners opportunity to link to local Manufacturing Extension Partnership (MEP) resources to assist in commercialization efforts**

When appropriate, ARS CRADA partners are provided a contact in their regional National Institute of Standards and Technology's Hollings Manufacturing Extension Partnership (MEP) office to provide manufacturing assistance. OTT works with MEP headquarters to identify those contacts. When a particular ARS Regional Forums (see USDA 7 initiative) has a manufacturing component, the regional MEP field staff is invited to provide an overview of the resources they have available to assist in manufacturing. Some MEP offices are part of ARS's ARP Network.

**USDA 10: Work with regional incubators and economic development organizations to identify opportunities for ARS scientists and ARS commercial partners**

This initiative directly addresses Section 4 of the Presidential Memorandum in establishing joint partnerships with university research parks, incubators, and other state / community economic development organizations. Since we have not yet been able to identify a project for the specific use of the University of Mississippi incubator's facilities, we expanded this initiative to include other incubators and economic development organizations. This expansion occurred through the Agricultural Research Partnerships (ARP) Network (see USDA 3 and section 3.4). Network members now include any organization interested in agriculture-based economic development such as, but not limited to: rural agribusiness, urban, community and/or economic development groups; organizations that support farmers, agritourism and/or food processors; and capital programs for business attraction and acceleration. Many economic development entities are members of our APR network, e.g., Montgomery County Department of Economic Development, Maryland Technology Development Corporation, Center for Innovative Food Technology, Innovate Mississippi, Nebraska Department of Economic Development, and California Association for Local Economic Development.

**USDA 11: Establishment of the "Branded Food Products Database for Public Health" Public-Private Partnership**

In FY 2013, ARS, the ATIP Foundation, and the International Life Science Institute North America (ILSI North America) established a public-private partnership to enhance the public's health through increased knowledge of the nutritional content of the nation's food supply. This will be accomplished by obtaining comprehensive food composition data from the food industry and making it available to government, industry, the scientific community and the general public through an enhanced USDA National Nutrient Database, developed and maintained by the ARS Nutrient Data Laboratory in Beltsville, MD.

In FY2015, the public-private partnership successfully beta tested a branded food products database. Five food manufacturers participated in a beta-test by providing product label data and nutrition information on 245 products through a GS1 certified data pool provider, FSEnet. These data were then passed to ARS for incorporation into the USDA National Nutrient Database.

**USDA 12: Evaluate various options for reducing license negotiation transaction costs**

Several proposals for establishing standard pre-commercialization license terms for all CRADA Subject Inventions were reviewed. Possible benefits included: creating business certainty for CRADA partners; providing an additional incentive to enter into a CRADA; and reducing transaction costs for both the CRADA partner and USDA. This initiative is now completed with the pre-negotiated license language as an option in the CRADA template to be used in situations where a CRADA partner has indicated that they would like to lock in the royalty rate before proceeding with the CRADA. In 2015, when appropriate, OTT has used pre-negotiated licensing terms to a CRADA partner.

**USDA 13: Develop Material Transfer Research Agreement (MTRA) as a new instrument to promote development and commercialization of materials from USDA**

USDA scientists create new materials that may have value in further research and development with the private sector. Material Transfer Agreements (MTA), widely used by USDA, only allow for the transfer of materials, but not engagement in joint research between the provider and the recipient of the materials. In order to enable some collaborative research with the material, in FY 2012 by combining the Material Transfer Agreement and the Trust Fund Cooperative Agreements authorities the MTRA was created. MTRAs are now reported as a metric in the Collaborative Relationships for Research and Development Table.

## 3.8. Metric Tables

**TABLE 1. Collaborative Relationships for Research and Development.**

\*ND- no data available.

Agricultural Research Service (ARS)	FY 2011	FY 2012	FY 2013	FY2014	FY2015
<b>Total number active CRADAs</b>	275	243	230	214	211
Active traditional CRADAs	190	180	182	160	151
Active non-traditional CRADAs	85	63	48	54	60
Active CRADAs with small businesses	ND	ND	116	96	98
<b>Number newly executed CRADAs, total</b>	78	53	62	43	59
Newly executed amendments <sup>1</sup>	91	82	86	72	76
Newly executed traditional CRADAs	57	39	41	29	44
Newly executed non-traditional CRADAs	21	14	21	14	15
Newly executed CRADAs with small businesses	ND	20	21	10	31
<b>Total number active MTRAs<sup>2</sup></b>	ND	12	100	188	212
Newly executed MTRAs	ND	12	86	105	102
<b>Total number of active other agreements<sup>3</sup></b>	13,007	13,835	12,717	12,953	12,375
Newly executed other agreements	1,525	1,119	1,776	1,808	1,862
<b>Number newly executed MTAs</b>	1038	970	991	906	743
Newly executed outgoing MTAs	672	661	647	506	513
<b>Total number of publications<sup>4</sup></b>	11,260	8,695	8,295	8,385	8,233
Peer-Reviewed Scientific manuscripts	5,279	5,027	4,922	5,209	4,871
Trade Journal manuscripts	83	86	93	85	76
Abstracts	3,773	3,582	3,280	3091	3,286

1. Amendments extend existing CRADAs for additional years to a maximum of 5 years, and/or change Statements of Work, and/or change funding levels.
2. Material Transfer Research Agreements. Involves collaborative research on a specific material.
3. Includes mostly Trust Fund Cooperative Agreements, Reimbursable Agreements, Non-Assistance Cooperative Agreements and Non-Funded Cooperative Agreements.
4. Number of manuscripts approved for submission to journal or magazine.

**TABLE 2. Invention Disclosure and Patenting**

ND- no data available.

Agricultural Research Service (ARS)	FY 2011	FY 2012	FY 2013 <sup>4</sup>	FY 2014	FY 2015
<b>Total number new invention disclosures<sup>1</sup></b>	126	137	165	101	193 <sup>5</sup>
University co-owned	22	66	46	37	40
Non-University co-owned	ND	ND	ND	ND	27
Based upon scientific discipline					
Biological Materials	ND	ND	ND	ND	32
Life science	61	59	74	39	64
Chemical	36	53	49	32	48
Mechanical & measurement	28	14	19	9	18
Plant patents <sup>3</sup>	7	17	12	4	3
Plant variety protection <sup>3</sup>	ND	ND	11	17	28
<b>Total number patent applications filed<sup>2</sup></b>	110	108	144	110	110
University co-owned	ND	ND	36	34	25
Non-University co-owned	ND	ND	ND	ND	26
Based upon scientific discipline					
Life science	ND	ND	62	47	47
Chemical	ND	ND	44	25	38
Mechanical & measurement	ND	ND	13	17	15
Plant patents	ND	ND	14	6	4
Plant variety protection	ND	ND	11	6	6
<b>Total number patents issued<sup>2</sup></b>	46	60	60	78	84
University co-owned	ND	ND	17	23	12
Non-University co-owned	ND	ND	ND	ND	20
Based upon scientific discipline					
Life science	ND	ND	17	36	33
Chemical	ND	ND	25	21	20
Mechanical & measurement	ND	ND	11	11	10
Plant patents	ND	ND	7	10	15
Plant variety protection	ND	ND	ND	ND	6

1. Inventions arising at the federal lab. For FY 2013 and 2014 also includes the plant protected through Plant Variety Protection.
2. Includes U.S. patent applications, foreign patent applications filed on cases for which no U.S. application was filed, divisional applications, continuation-in-part applications, provisional applications, and Plant Variety Protection.
3. Plants may be protected in one of two ways based upon their mode of reproduction- patent (vegetatively reproduced) through the USPTO or variety protection (seed reproduced) through USDA-AMS.
4. FY 2013 numbers were revised (higher) in FY 2014.
5. FY 2015 includes the addition of Biological Material Invention Disclosures.

**TABLE 3. Profile of Active Licenses**

\*ND- no data available.

Agricultural Research Service (ARS)	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
<b>Total number active licenses</b>	337	363	380	392	404
Executed to small businesses <sup>1</sup>	ND	118	137	150	147
Executed to startup businesses <sup>2</sup>	ND	ND	11	12	12
Executed to universities	ND	142	169	168	175
Amended in FY	ND	ND	ND	10	5
Invention licenses <sup>3</sup>	301	321	331	341	339
Executed to small businesses	ND	ND	113	125	112
Executed to startup businesses	ND	ND	11	12	12
Executed to universities	ND	ND	162	160	166
Other IP Licenses <sup>4</sup>	36	42	49	51	65
Executed to small business	ND	ND	24	25	35
Executed to startup businesses	ND	ND	0	0	0
Executed to universities	ND	ND	7	8	9
<b>Total number newly executed licenses</b>	33	31	23	28	35
Executed to small businesses	ND	15	9	15	16
Executed to startup businesses	ND	ND	0	1	0
Executed to universities	ND	12	10	10	9
Invention licenses			17	26	20
Executed to small businesses	ND	ND	5	14	5
Executed to startup businesses	ND	ND	0	1	0
Executed to universities	ND	ND	10	10	8
Other IP Licenses			6	2	15
Executed to small businesses	ND	ND	4	1	11
Executed to startup businesses	ND	ND	0	0	0
Executed to universities	ND	ND	0	0	1

1. A small business, together with its affiliates, must not have more than 500 employees.
2. For the purpose of this report, a startup company is a privately-held, U.S., for-profit company operating for less than 5 years and actively seeking financing to commercialize a federal scientific work product.
3. Invention licenses refer to patents and plant variety protection certifications.
4. Other IP licenses refer to biological materials licenses.

**TABLE 4. Characteristics of Income Bearing Licenses**

Agricultural Research Service (ARS)	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
<b>Total number of income bearing licenses</b>	335	360	378	390	402
Exclusive	239	259	273	278	274
Partially exclusive	16	14	13	15	11
Non-exclusive	80	87	92	97	117
<b>Invention licenses<sup>1</sup></b>	299	318	329	339	337
Exclusive	234	252	265	269	266
Partially exclusive	16	14	13	15	11
Non-exclusive	49	52	51	55	60
<b>Other IP Licenses<sup>2</sup></b>	36	42	49	51	65
Exclusive	5	7	8	9	8
Partially exclusive	0	0	0	0	0
Non-exclusive	31	35	41	42	57
<b>Total number royalty bearing licenses</b>	130	128	134	131	139
Invention licenses	119	114	115	117	121
Other IP licenses	11	14	19	14	18

1. Invention licenses refer to patents and plant variety protection certifications.

2. Other IP licenses refer to biological materials licenses.

**TABLE 5. Income from Licensing**

\*ND- no data available.

Agricultural Research Service (ARS)	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
<b>Total income all active licenses</b>	\$3,989,228	\$3,806,164	\$4,385,952	\$4,927,938	\$5,066,988
Invention licenses <sup>1</sup>	\$3,854,820	\$3,670,692	\$4,053,931	\$4,733,200	\$4,842,256
Other IP licenses <sup>2</sup>	ND	ND	\$332,021	\$194,738	\$224,732
<b>Total earned royalty income (ERI)</b>	\$3,136,813	\$3,059,989	\$3,353,876	\$3,610,774	\$3,509,904
Median ERI	\$4,748	\$5,000	\$3,609	\$3,232	\$3,525
Minimum ERI	\$6	\$44	\$5	\$32	\$13
Maximum ERI	\$630,847	\$757,219	\$856,987	\$575,753	\$728,017
ERI from top 1% of licenses	NP <sup>3</sup>				
ERI from top 5% of licenses	\$1,932,197	\$1,752,367	\$1,969,155	\$2,048,317	\$1,756,460
ERI from top 20% of licenses	\$2,672,414	\$2,604,008	\$2,892,796	\$3,103,143	\$2,856,924
<b>ERI distributed</b>					
Inventors	\$1,391,111	\$1,206,713	\$1,192,808	\$1,305,695	\$1,632,130
Funds to be used for salaries	ND	ND	ND	\$2,812,269	\$2,819,906
Patent filing preparation, fees, & annuity payments paid <sup>4</sup>	ND	ND	ND	\$809,974	\$621,701

1. Invention licenses refer to patents and plant variety protection certifications.

2. Other IP licenses refer to biological materials licenses.

3. Not presented, represents one license.

4. Approximately 40% is reimbursed when licensed.

**TABLE 6. Licensing Management: Elapsed Execution Time and Termination**

Agricultural Research Service (ARS)	FY 2011 <sup>1</sup>	FY 2012 <sup>2</sup>	FY 2013 <sup>3</sup>	FY 2014 <sup>4</sup>	FY 2015 <sup>5</sup>
<b>All licenses</b>					
- average (months)	5.9	5.8	3.5	5.9	2.8
- median (months)	3.3	4.2	2.3	5.8	2.5
- minimum (months)	0.6	0.3	0.4	0.9	0.5
- maximum (months)	18.2	19.7	12.5	21.5	10.0
<b>Licenses terminated for cause</b>	0	0	0	0	0

- <sup>1</sup> During FY 2011, USDA received 29 new invention license applications, for which 4 new licenses were granted, 21 license agreements are currently in negotiation, 0 applications were withdrawn by the applicants, and 4 applications are on hold by request of the applicant. The FY 2011 data is based upon 13 licenses granted to commercial licensees and does not include licenses executed with universities for co-owned inventions. In accordance with 35 USC 202(e), such licenses are granted for the purpose of consolidating rights in the invention, and therefore license applications are not required.
- <sup>2</sup> During FY 2012, USDA received 16 new invention license applications, for which 7 new licenses were granted, 9 license agreements are currently in negotiation, 0 applications were withdrawn by the applicants, and 0 applications are on hold by request of the applicant. The FY 2012 data is based upon 18 licenses granted to commercial licensees and does not include licenses executed with universities for co-owned inventions. In accordance with 35 USC 202(e), such licenses are granted for the purpose of consolidating rights in the invention, and therefore license applications are not required.
- <sup>3</sup> During FY 2013, USDA received 28 new invention license applications, for which 8 new licenses were granted, 15 license agreements are currently in negotiation, 3 applications were withdrawn by the applicants, and 2 applications are on hold by request of the applicant. The FY 2012 data is based upon 18 licenses granted to commercial licensees and does not include licenses executed with universities for co-owned inventions. In accordance with 35 USC 202(e), such licenses are granted for the purpose of consolidating rights in the invention, and therefore license applications are not required.
- <sup>4</sup> During FY 2014, USDA received 15 new invention license applications, for which 8 new licenses were granted, 5 license agreements are currently in negotiation, 2 applications were withdrawn by the applicants, and 0 applications are on hold by request of the applicant. The FY 2014 data is based upon 17 licenses granted to commercial licensees and does not include licenses executed with universities for co-owned inventions. In accordance with 35 USC 202(e), such licenses are granted for the purpose of consolidating rights in the invention, and therefore license applications are not required.
- <sup>5</sup> During FY 2015, USDA received 42 new invention license applications, for which 21 new licenses were granted, 18 license agreements are currently in negotiation, 2 applications were withdrawn by the applicants, and 1 application is on hold by request of the applicant. The FY 2015 data is based upon 26 licenses granted to commercial licensees and does not include licenses executed with universities for co-owned inventions. In accordance with 35 USC 202(e), such licenses are granted for the purpose of consolidating rights in the invention, and therefore license applications are not required.

### 3.9. Downstream Outcomes



## NUTRITION, FOOD SAFETY, QUALITY

### National Program:

- **Human Nutrition, NP 107**
- **Food Safety, NP 108**
- **Quality and Utilization of Agricultural Products, NP 306**

### Survey.

Every 5 years USDA's Food Safety Inspection Service (FSIS) assesses the background levels of persistent organic pollutants—including dioxins, furans, polychlorinated biphenyls, and polybrominated diphenyl ethers—in U.S. beef, pork, turkey, and chicken. Data derived from this assessment are used to determine whether background levels of these contaminants are increasing or decreasing in food animals. ARS researchers in Fargo, North Dakota, collected over 500 samples of fat from U.S. slaughter facilities for 13 months and then analyzed the samples for dioxins and dioxin-like compounds. Study results indicated that levels of dioxin and dioxin-like compounds have remained consistently low in the U.S. meat supply and are continually decreasing. The data are being disseminated by U.S. regulatory officials as evidence that the quality of the U.S. meat supply is increasing as the level of dioxin-like persistent organic pollutants declines. (Project No. 544232000-013-00D)

### Food portion sizes for children are predicted by parental characteristics.

In the first study to examine parental behavioral influences on children's food portion sizes, ARS-supported scientists examined the feeding habits of 145 mostly Hispanic and African-American parents of preschoolers. The marked increase in obesity among young children has not been explained well despite intensive research, much of which has focused on child behaviors. During three at-home meals, the researchers measured and analyzed how much food parents and children were served and consumed. The amounts parents served themselves was a significant predictor of how much food the children were given, which in turn, was highly correlated with the amounts they ate. African-American parents served more food to themselves and to their children than Hispanic parents, and employed parents served larger meals than those who were unemployed. Body mass index, the standard measure of obesity, was not predictive of meal size. These results suggest that educating parents about appropriate portion sizes for children and how parental choices at the dinner table may affect eating habits in children. This information could support efforts to improve U.S. nutrition for children and adults. (Project No. 6250-51000-053-00D)

**The current standard for calorie intake in children is set too high.**

Current Dietary Reference Intake (DRI) standards are based on previous studies that included only two 3-year-olds and two 4-year-olds and did not address how substantial differences in physical activity level might affect energy needs. ARS-funded researchers in Houston, Texas, determined that DRI standards overestimate the calories required to meet the energy needs of preschool children. The researchers included 97 children in a study of total energy expenditure, short-term metabolic needs, and long-term metabolic needs. Results indicated that the current DRI for energy overestimates caloric need, and that physical activity has a large role in determining that need and can sometimes increase caloric demand by almost 600 calories per day. This research will support nutritionists who provide guidance on appropriate caloric intake levels for children, and may help stem the increase in childhood obesity over the last 30 years. (Project No. 6250-51000-053-00D)

**Children suffering from severe acute malnutrition improve more quickly with amino acid supplements.**

In many developing countries, malnutrition of young children remains a major cause of stunting and may result in permanent deficits that prevent people from reaching their full physical and mental potential. Aid programs often provide special foods that induce acute recovery of growth, but that is often not maintained over the long term. ARS supported scientists studied 22 children from the West Indies who lagged behind their peers in growth by more than 20 percent. The children in the study ranged in age from 4 to 31 months. A mixture of aromatic amino acids (AAA) not normally used to treat malnutrition was compared with the same amount of a standard, single amino acid, and was found to increase whole-body protein synthesis and provided better amino acid balance during catch-up growth. These results can be used by government agencies to administer more effective nutrition support to the most vulnerable children by including AAA in nutritional rehabilitation regimens. (Project No. 6250-51000-052-00D)

**Multiple detrimental effects of maternal obesity on placenta and fetus documented.**

ARS-supported scientists have shown that maternal obesity can damage the placenta by increasing inflammation, oxidative stress, and other toxic responses caused by elevated fat levels. Even though the placenta is the biological interface between mother and developing baby, there has been limited interest in its biology because it is expelled after birth. In this study, placental tissue in women who were obese and of healthy weight was assessed for activity changes in 288 genes. The scientific team also characterized the set of all RNA molecules in the placental tissue that translate the genetic material coded by DNA into protein production. Although guidelines exist for weight gain during pregnancy, many women are overweight or obese before conception and many gain far more than recommended during pregnancy. This cutting-edge information is an essential part of identifying metabolic pathways regulating placental physiology and how this may go awry in the presence of obesity or other diseases. (Project No. 6251-51000-007-00D)

**Regulation of milk production in humans.** ARS-funded scientists provided the first documentation that a number of women struggle to successfully breastfeed their infants, particularly mothers who are obese, teenage, or with premature infants. The researchers developed a method for isolating and measuring the messenger RNA that help regulate milk production and traced the changes in gene expression over the first 42 days of lactation in normal women. The primary trigger for the start of lactation in humans is incompletely understood, but one of the factors is the withdrawal of progesterone (a hormone made in the placenta during pregnancy) once the placenta is removed from the mother after giving birth. This suggests it may be possible to develop therapeutic approaches for blocking the action of progesterone, which could increase the success rates of breastfeeding. Supporting efforts to provide mothers and infants with all of the benefits of breastfeeding enhances childhood nutrition and health. (Project No. 6250-51000-054-20S)

**Physical activity benefits elderly adults at high risk for impaired mobility.**

Sarcopenia is the loss of skeletal muscle mass in the elderly, and it contributes to declines in physical capacity and performance with advancing age. The economic impact of sarcopenia has been estimated at \$18.5 billion annually. ARS-funded researchers in Boston, Massachusetts, have determined that structured physical activity is a feasible and effective intervention to reduce the burden of disability among vulnerable older persons in late life. Men and women (aged 70-89 years) who were able to walk and volunteered for the study were assigned to

participate either in moderately intense physical activity that included aerobic, resistance, and flexibility training activities or in a health education program that included workshops on topics relevant to older adults and upper extremity stretching exercises. Thirty percent of the participants engaging in the physical activity program exhibited major mobility impairments, whereas 36 percent of participants in the health education program exhibited major mobility impairments. Notably, a subgroup with lower physical function at the beginning of the study received considerable benefit from the physical activity intervention. These results support USDA's goal of improving health and safety for citizens of all ages. (Project No. 1950-51000-068-00D)

**Worksite weight-loss interventions.**

Obesity is a serious health crisis in the United States, contributing to increasing health care costs, which in turn, negatively affect the Nation's competitiveness. Effective, sustainable weight control programs for employees are urgently needed. After completing a pilot study of a new worksite weight loss intervention, ARS-funded researchers in Boston, Massachusetts, reported an average participant weight loss of 8 percent over 6 months with no significant weight regain among participants 12 months after the start of the intervention. In this study, the worksite intervention had a dropout rate of only 11 percent, which indicates that in addition to the other positive results, participants found the program to be acceptable. Workplace intervention may be an important tool in addressing the national obesity epidemic because it has the potential to be more effective in retaining program participants and preventing weight regain, both of which are significant factors in the ineffectiveness of comparable programs. (Project No. 1950-51000-071-00D)

**Dietary intake of vegetables and fruit can be estimated by a noninvasive skin test.** Increasing the consumption of fruits and vegetables is a primary recommendation of nutritionists, yet few ways exist to accurately measure changes in intake of these foods. Carotenoid concentrations (chemicals similar to vitamin A) in the blood are considered the best marker of consumption of fruit and vegetable intake by humans, but blood collection is invasive and not practical for large-scale studies. This method was recently utilized in a human study that fed varying levels of vegetables and fruits for 28 weeks. The laser method accurately detected changes in the consumption of carotenoid-containing foods, and the values obtained by the laser correlated well with plasma carotenoid concentrations. This method will make determination of dietary intake of fruits and vegetables much easier to assess and may become a valuable tool for both researchers and clinicians. (Project No. 5450-51000-049-00D)

**Cooking of food produces advanced glycation end products but does not adversely affect health.**

When food is heated to high temperatures, the browning reaction generates advanced glycation end products (AGEs). Published studies on AGEs have been highly controversial, but many have associated them with several chronic diseases, especially cardiovascular disease. ARS scientists addressed this question in a new study of healthy, middle-aged adults who were given diets for 6 weeks prepared at either high or mild temperatures. The distinguishing features of this study were provision of all foods that were the same in both diets, providing identical calories, and well controlled heating of foods. A number of risk factors for heart disease, including functional tests of the blood vessels, plus multiple serum and urinary proteins that indicate inflammation, were measured. No adverse effects of the high AGE diet were observed for any indicators. This is the first fully controlled study to examine this question and clearly indicates that cooking food at usual temperatures does not have detrimental effects on the cardiovascular system. (Project No. 1235-51530-009-00D)

**New analytical method for nitrosamines and risk assessment by USDA.**

Nitrosamine levels in fried bacon were a major concern 30 years ago before steps were taken to reduce their formation, however, nitrosamines levels have not been monitored since the 1990s. The USDA Office of Inspector General (OIG) requested the Food Safety Inspection Service (FSIS) to conduct a survey of nitrosamine formation from cooked bacon and an accompanying risk assessment to check if the situation had changed. The previous analytical methods used for nitrosamines were unwieldy and used archaic specialized equipment that was unavailable. At the request of the Food Safety Inspection Service (FSIS), ARS scientists in Wyndmoor, Pennsylvania developed and validated a new sensitive, rapid, and easy test for assessing nitrosamine levels in fried bacon. An innovative new approach detected as little as 0.1 ng/g levels of the nitrosamines of concern in the

complex samples. FSIS regulators performed a risk assessment using the survey results and demonstrated that frying bacon did not generate levels of nitrosamines that posed a health risk. As a result of this work, nitrosamines in fried bacon do not need to be routinely monitored. Testing and survey methods will be readily available to FSIS and others if another survey is needed. ARS' research also helped close out the longest OIG audit in FSIS. (Project No. 1935-42000-056-00D)

**Impact of tetracycline on *Salmonella*.**

Multi-drug resistant (MDR) *Salmonella*, a bacterium that can cause foodborne illness, is an important food safety concern. The development of antibiotic resistance to tetracycline, which is a commonly used antibiotic in both humans and animals, is very common. ARS scientists in Ames, Iowa, examined the impact of tetracycline on the virulence of MDR *Salmonella typhimurium* and found that tetracycline promoted the ability of some MDR *Salmonella* to invade host cells. This suggests that tetracycline may play a role in increasing the virulence of MDR *Salmonella*, and highlights the need to develop alternative treatments for *Salmonella* and other bacterial diseases. (Project No. 3625-32000-101-00D)

***Salmonella enteritidis* contamination of eggs from hens housed in conventional or enriched cages.**

Many human foodborne illnesses result from eating eggs contaminated by *Salmonella enteritidis*, which is transmitted to eggs by infected chickens. ARS researchers in Athens, Georgia, determined that housing experimentally infected hens in conventional or enriched cages (larger cages with perches and other enhancements) did not affect how often eggs became internally contaminated with *Salmonella*. These results demonstrate that housing egg-laying hens in enriched cages may not reduce the production of eggs contaminated by *S. enteritidis* and that other options should be considered to reduce foodborne illness from contaminated eggs. (Project No. 661232420-001-00D)

***Salmonella* behavior on chicken during cold storage.**

Refrigerated chicken sold in stores is usually contaminated with low levels of *Salmonella*, a pathogen that can cause foodborne illness unless it is destroyed by cooking. When consumers store chicken in refrigerators that are too warm, *Salmonella* populations can multiply. ARS researchers in Princess Anne, Maryland, conducted studies that assessed the growth of *Salmonella* on chicken meat in cold storage. No *Salmonella* growth was observed on chicken stored at 26 to 50 degrees F, but at 54 to 61 degrees F, *Salmonella* growth was highest on dark meat, intermediate on skin, and lowest on white meat. The researchers used these findings to develop and validate a computer model that predicts *Salmonella* growth and survival on chicken stored at temperatures between 26 to 61 degrees F. The new model will help the chicken industry, regulatory agencies, and consumers better predict and manage the risk of developing foodborne illness from consuming chicken contaminated with *Salmonella*. (Project No. 1935-42000064-00D)

**Genomic differences in transient and persistent strains of *Salmonella* Kentucky on a dairy farm.**

There can be considerable variation both within and between different types of *Salmonella*. There is also significant variation in the pathogen's ability to colonize hosts and in the severity of illness associated with contamination or infection. Two types of *Salmonella* Kentucky were isolated from a dairy herd 6 years apart. While one strain was isolated transiently in the herd, the other was associated with long-term asymptomatic infection. Whole-genome sequencing revealed the two types had genetic differences that are linked to the ability to colonize the bovine intestine and in the ability to repress virulence. Repressing virulence reduces the host immune response to the bacteria and increases the pathogen's potential for successful long-term colonization. These findings will help scientists elucidate the genetic factors affecting pathogen colonization and virulence expression, and support the development of strategies to disrupt or prevent infection of foodborne pathogens in production animals. (Project No. 1245-32000-091-00D)

**Rapid in-field detection of *E. coli* that produce Shiga toxin.**

*Escherichia coli* (*E. coli*), a pathogen that produces Shiga toxin, is a significant contamination risk to the food supply. ARS researchers in Riverside, California, and California Polytechnic University collaborators designed and evaluated field methods that can be used to rapidly detect *E. coli* within 5 to 10 minutes. When fully

optimized, the detection procedure could be used directly in the field or wherever necessary for rapid, real-time detection of *E. coli*, which will enable food safety managers to quickly eliminate Shiga toxin from the target area and restore baseline conditions needed for safe food production. (Project No. 5310-32000-003-00D)

***E. coli* O157:H7 strains from contaminated raw beef trim during “high event periods.”**

The U.S. beef processing industry has developed and implemented effective antimicrobial interventions that have dramatically reduced the incidence of beef trim contamination by *E. coli* O157:H7, a pathogen that can cause severe foodborne illness. However, individual processing plants still experience sporadic peaks in contamination rates where clusters of multiple finished product contamination occur in a short time frame. These peaks have been referred to as “high event periods” (HEP) of contamination. ARS scientists in Clay Center, Nebraska, determined that each HEP is linked to one type of *E. coli* O157:H7 isolate that is responsible for most, if not all, of the contamination. This is in contrast to the range of different strains identified on the hides of cattle entering processing plants and poses a potential challenge to the current model for finished product contamination during beef processing. In addition, it was found that a high proportion of HEP are caused by strain types associated with human illness. This research indicates that beef processing plants will need additional support in developing tools and techniques to control HEP. (Project No. 5438-42000-014-00D)

**Determining set-back distances between feedlots and leafy greens to reduce pathogen contamination.**

Experts suspect that cattle may have been the source of *E. coli* O157:H7 pathogens responsible for recent outbreaks of foodborne illness linked to spinach and lettuce consumption. These outbreaks underline the importance of determining how much distance is needed between animal production facilities and crop fields to reduce the risk of *E. coli* O157:H7 transmission and associated outbreaks of foodborne illness. Current guidelines for leafy green growers recommend maintaining a provisional distance of 400 feet between concentrated animal feeding operations and leafy green crop fields. ARS scientists in Clay Center, Nebraska, evaluated how *E. coli* O157:H7 contamination of leafy green produce crops was affected by the proximity of a beef cattle feedlot. Low levels of *E. coli* O157:H7 were recovered in leafy greens at all setback distances in the study, including a 600-foot setback. These results suggest that the current leafy green field distance guidelines of 400 feet may not be sufficient to mitigate the migration of *E. coli* O157:H7 from concentrated animal feeding operations into nearby crop fields. This information is critical for understanding the risks associated with growing leafy greens in close proximity to cattle production, and for determining safe distances between cattle feedlots and produce. (Project No. 5438-32000-030-00D)

**Role of plant cultivation conditions on *E. coli* internalization.**

Hydroponic farming practices have increased in recent years, but little is known about how hydroponic production affects *E. coli* uptake into the internal vascular system of fresh produce. ARS scientists in Beltsville, Maryland, grew spinach in hydroponic systems and in soil contaminated with *E. coli* O157:H7 and then measured *E. coli* uptake in plant roots, stems, and leaves at set intervals during production. Their results indicated that *E. coli* O157:H7 could enter hydroponically-grown spinach plants through the root system and migrate to the stems and leaves. When the root system in hydroponically-grown spinach was wounded, *E. coli* O157:H7 internalization and migration to the edible portions of the plant increased. However, plants grown in *E. coli*-contaminated soils had greater levels of *E. coli* internalization than plants grown hydroponically, and *E. coli* uptake was not affected by *E. coli* O157:H7 Curli expression—a type of bacterial structure that is found on the surface of *E. coli*—or by spinach cultivar. This work shows it is possible for *E. coli* to internally contaminate hydroponically-grown produce, even though overall contamination levels may be lower than plants grown in soil. (Project No. 1245-32420-005-00D)

**AflaGoggles for screening aflatoxin contamination in maize.**

Aflatoxins are a potent toxin that can infect corn and other important food crops, but detecting aflatoxin contamination in harvested grain can be difficult, especially in countries that lack high-tech monitoring tools. ARS scientists in New Orleans, Louisiana, developed special goggles based on hyperspectral technology—which detects light waves in the visible and non-visible part of the light spectrum—that inspectors can use to identify aflatoxin-contaminated grain that needs to be removed from the rest of the grain. A licensing agreement for the

technology was signed with Mississippi State University and Secure Food Solutions, a company based in Tennessee, and a U.S. Patent was issued to “Method and Detection System for Detection of Aflatoxin in Corn with Fluorescence Spectra” (Patent Number 8,563,934). If the prototype goggle that was developed is successful, they will provide African farmers with a rapid and inexpensive method for detecting aflatoxin in their corn crops, which will significantly increase the safety of their food supply. (Project No. 6435-42000-021-00D)

**Cure for perennial aflatoxin problems in Kenya.**

Fungal infections of food crops can result in the production of aflatoxins, which is a carcinogen that also causes other serious acute and chronic illness in human and animals. Food crops—particularly maize—have been most severely contaminated in Kenya, where illness and death from aflatoxin exposure has been documented for decades. ARS researchers in Tucson, Arizona, collaborators at the International Institute of Tropical Agriculture, and Government of Kenya researchers partnered to use *Aspergillus flavus* fungi in the development of a biocontrol product that protects food crops from aflatoxin contamination. They tested the resulting biocontrol in selected Kenya counties and determined that the product was highly effective at preventing aflatoxin contamination of maize in these target counties. Findings also indicated that Kenyans are frequently exposed to very high aflatoxin concentrations (more than 50 times the concentrations allowed in U.S. pet food), which has resulted in an ongoing human health crisis. Developing an aflatoxin biocontrol for area-wide use in Kenya will substantially reduce the human health risk associated with aflatoxin exposure and will provide useful lessons for the development and use of next-generation biocontrol products in the United States. (Project No. 5347-42000-020-00D)

**Elevated CO<sub>2</sub> reduces maize defenses to *Fusarium verticillioides* infection.**

High temperatures and drought associated with climate change can support growth of the fungus *Fusarium verticillioides*, which increases fumonisin contamination and the development of mycotoxins in corn crops. However, there is limited information about how elevated carbon dioxide (CO<sub>2</sub>) will affect fungal disease and mycotoxin contamination. ARS scientists in Peoria, Illinois, and Gainesville, Florida, have shown when corn is grown in elevated CO<sub>2</sub> levels, plant defenses are weakened. *F. verticillioides* infections are able to increase as a result, but there is also a relative decrease in the production of mycotoxin. These findings provide a clearer understanding of how elevated CO<sub>2</sub> levels will affect plant-mycotoxin interactions and supports the development of cost-effective agricultural practices that minimize potential economic losses in the face of future climate change. These findings also provide information about the physiological conditions associated with reduced mycotoxin production during the host plant-pathogen interactions, which will assist in identifying host plant traits and genes that modulate mycotoxin formation and developing novel approaches for reducing mycotoxin contamination in corn. (Project No. 3620-42000042-00D)

**Chlorine by-product formation in wash water and fresh-cut produce.**

Chlorine (sodium hypochlorite) is commonly used as a sanitizer by the food industry and citric acid is often used to adjust its pH and increase its efficacy. However, adding citric acid can also result in the formation of chlorine by-products that are a potential health risk. ARS researchers in Wyndmoor, Pennsylvania, studied the formation of the chlorine by-product trichloromethane in water and fresh-cut produce and assessed how the by-product was affected by citric acid. Results showed that citric acid reacted with chlorine and produced significant amounts of trichloromethane in chlorinated water, but not in chlorine dioxide solution. Higher amounts of trichloromethane were produced in the chlorine solution used for washing cut-lettuce than in the solution used for diced onions, and trichloromethane levels in the final products (cut vegetables) were much lower than levels in the water. These results indicate that citric acid should be replaced with other pH adjusters to reduce the formation of trichloromethane in wash water. These findings can be used by the produce industry to minimize the formation of chlorine by-products in water and fresh produce, and reduce potential health risks associated with food processing. (Project No. 1935-41000-092-00D)

**Improved capacities for estimating microbial water quality.**

Modeling microbial water quality is based on estimating the survival rate of livestock waste microorganisms after they have been deposited on land via excretion. ARS scientists in Beltsville, Maryland, have created the world's

largest database on how long *E. coli* pathogens in soils and in animal waste survive after they have been deposited on land. The scientists used predictive microbiology to simulate how temperature affected *E. coli* survival in different types of animal waste and manures. These results will contribute to improving the accuracy of microbial water quality models used to assess and predict microbial loads in recreational and irrigation water sources, and directly address issues included in the Produce Rule under the FDA Food Safety Modernization Act. (Project No. 1245-12630-008-00D)

**Identification of *Campylobacter* flagellar capping protein as a potential vaccine candidate.**

Vaccination is a potential method to prevent and control foodborne pathogens in animals, including *Campylobacter jejuni*. ARS researchers in Athens, Georgia, screened a number of *C. jejuni* proteins against blood serum from infected broilers and breeder chickens and observed that the pathogen's flagellar capping protein reacted strongly to pathogen antibodies in the serum. Since this protein is very similar among *Campylobacter* species, it could serve as a potential candidate for a vaccine that could reduce infection in chickens and increase the safety of the food supply. (Project No. 6612-32000-060-00D)

**Gut microbiota affects vaccine responses.**

The role of the human biome—all the microorganisms that live in the human body—in maintaining human health is receiving a great deal of scientific attention. Research by ARS scientists and colleagues indicate that the composition of the microbial community inhabiting the human intestine is likely to have a profound influence on both infant and adult health. ARS scientists in Davis, California, worked with World Health Organization and other collaborators to conduct a study among healthy Bangladeshi infants up to 15 weeks of age to determine whether intestinal microorganisms are associated with standard vaccine responses. Based on DNA obtained from feces, the scientists determined that a high abundance of certain types of intestinal bacteria was associated with stronger responses to several vaccines, including oral polio vaccine, tetanus toxoid vaccine, and tuberculosis vaccine. Multiple measures of vaccine response were affected, including antibody response, hypersensitivity skin test response, and T-cell proliferative response. These findings suggest that interventions that use live bacteria or appropriate foods to promote a healthy microbial community in the gut may improve the efficacy of vaccination programs and could have positive effects on childhood health. (Project No. 5306-51530-022-00D)

**Changes in gut bacteria are associated with alterations in liver and kidney function.**

ARS researchers have discovered weight loss and exercise in sedentary, obese insulin-resistant women leads to novel patterns of plasma metabolites that indicate better metabolic health. Research in recent years has shown that metabolic products from bacteria in the large intestine are absorbed into the bloodstream and may influence metabolism at distant sites in the body. Although the bacteria in the large intestine are readily influenced by diet, it remains largely unknown how such changes affect a person's overall health. But in this study, in addition to finding that exercise and diet resulted in novel plasma metabolite patterns, the ARS scientists also determined that blood metabolites that had originated from colon bacteria indicated better insulin resistance and better efficiency of mitochondria, the cell organs responsible for energy metabolism. With the majority of Americans being overweight or obese, the incidence of type 2 diabetes has more than doubled and has become a leading cause of disability and health care costs, and insulin resistance is the classic diagnostic feature of type 2 diabetes. These results indicate the need to consider both bacterial and organ metabolism to develop a comprehensive understanding of how diet helps to normalize insulin metabolism. (Project No. 5306-51530-019-00D)

**Commercial application for *Vibrio* predatory bacteria.**

The bacterium *Vibrio* is the primary cause of shellfish associated bacterial illness and death in the United States. While evaluating the effects of pH, temperature, and algae diet on *Vibrio* levels in shellfish, ARS researchers in Dover, Delaware, and University of Delaware collaborators discovered a group of naturally occurring predatory bacteria that substantially reduce *Vibrio* levels in seawater and shellfish. ARS researchers are collaborating with the U.S. Food and Drug Administration and industry partners to assess the use of these *Vibrio* predators for eliminating or significantly reducing vibrio levels in market shellfish. As part of this effort, a pilot-scale, portable processing facility is being evaluated to determine the effectiveness of *Vibrio* predatory bacteria in eliminating *Vibrio* in oysters. If this process is successful, it could result in the direct application of a technology developed

by ARS to manage the most significant pathogens in oysters and clams associated with foodborne illness and enhance shellfish safety worldwide. (Project No. 1935-42000-065-00D)

**Organic milk is more abundant in healthy omega-3 fatty acids than conventional milk.**

Scientific evidence shows that omega-3 and other fatty acids in dairy products are advantageous to human health. ARS researchers in Wyndmoor, Pennsylvania, investigated milk from two adjacent dairy farms, one producing conventional milk, the other organic milk from pasture-fed cows. Linolenic acid, an omega-3 fatty acid associated with benefiting the brain and a healthy heart, was significantly higher in the organic milk throughout the year. Americans may benefit from consuming dairy foods with higher levels of healthy fatty acids as part of a balanced diet. (Project No. 1935-41000-091-00D)

**Native Texas shrub produces potent mosquito repellents with a longer-lasting effect than DEET.**

Mosquitoes serve as carriers of human diseases such as malaria, dengue, and yellow fever. An ARS scientist in Oxford, Mississippi, synthesized an analog of a natural chromene compound that is more repellent than DEET with a longer duration of action. The compound was isolated from *Amyris texana*, a plant native to Texas. A patent for the compound has been filed. In follow-up studies, several chromene derivatives were further synthesized and shown to be even more potent mosquito repellents with longer action than DEET. This study reveals the potential use of chromene analogs and their action as mosquito repellents, and as superior substitutes for DEET. (Project No. 6408-41000-008-00D)

**Native cedar wood oil is a highly effective repellent to several insect pests.**

The oil from the American native cedar tree *Juniperus virginiana* is an effective repellent to several species of ants and houseflies, two cockroach species, and a tick species. ARS scientists in Peoria, Illinois, developed a method to extract cedar wood oil (CWO), a safe, natural, native, renewable and underutilized agricultural resource, and demonstrated its potential use as an insect control agent. In outdoor tests, several species of ants were repelled by smearing CWO on a pole leading to a sugarwater solution. In laboratory tests, invasive, imported red fire ants were repelled by CWO separating them from food. Blacklegged tick nymphs were killed by CWO, and more than 90 percent of adult houseflies died after contact with CWO. The crude carbon dioxide-derived CWO extract showed some repellence toward both German and American cockroaches. (Project No. 3620-41000-150-00D)

**Vegetable oil estolides are high-performing, fuel-saving, renewable lubricants.**

Renewable, bio-based lubricants are in great demand. Estolides are fluids made from renewable animal- and vegetable-based oils. Combining estolides with alcohol results in a lubricant that performs better at colder temperatures, reduces friction and wear, and lowers fuel consumption. ARS scientists in Peoria, Illinois, refined and improved the estolide properties and solved largescale batch-production challenges such as incomplete fatty acid conversion. This new technology was transferred to an industrial partner for commercialization. (Project No. 3620-41000-158-00D)

**Safe, chemical-free method for cotton defoliation and desiccation.**

Recent studies have demonstrated that prolonged exposure to certain chemicals used in cotton pre-harvesting may be associated with an elevated risk for Parkinson disease. Several regulatory agencies are examining a potential ban on the use of these chemicals. ARS engineers in Lubbock, Texas, have discovered a new, safe, chemical-free method to defoliate and desiccate cotton. The new technology has been patented. It offers a safe, valuable, alternative to using hazardous harvest-aid chemicals and has garnered interest and financial support from a major stakeholder in the cotton industry. (Project No. 6208-21410-007-00D)

**Calcium sprays make red and blue fruits and vegetables even more colorful and healthier.**

Anthocyanins, the compounds that cause the red and blue coloration of fruits and vegetables, are also recognized as having antiinflammatory and anti-carcinogenic activity, and the potential to prevent cardiovascular disease, control obesity, and alleviate diabetes. ARS scientists in Beltsville, Maryland, identified the genes that control anthocyanin accumulation in strawberries. Further research found that strawberry plants sprayed with calcium

boosted expression of the anthocyanin regulator genes and made the fruit even redder. Strawberry is an economically important crop, and these results may help plant breeders and growers enhance the color and health benefits of the fruit. (Project No. 1245-43000-012-00D)

**Calcium in guayule production improves rubber yields.**

Guayule is a woody desert crop native to the United States that is being used to produce natural rubber and bioenergy. ARS scientists in Albany, California, developed a tissue culture-media protocol using calcium nitrate to grow plants with more and longer shoots. Information from this research will be useful in establishing guayule seedlings in greenhouses and in eventual field production, and should lead to more abundant natural rubber production. (Project No. 5325-21410-020-00D)

**Non-destructive, rapid detection and removal of fly-larvae-infested olives saves money.**

Olive-fly infestation decreases fruit yield, decreases the value of olive oil, makes it unsuitable for virgin oil production, and may result in the rejection of entire lots of olives for food consumption purposes. Detecting and removing infested olives before they are used in food or oil production improves fruit quality and saves growers and processors millions of dollars. ARS researchers in Albany, California, have developed a non-destructive method of using X-rays to rapidly detect infestation of olive-fly larvae on fruit in high-speed processing systems. Combined with near infrared spectroscopy, the two technologies allow real-time removal of infested olives from processing lines, and higher quality and marketability of American olive products. (Project No. 5325-44000-010-00D)

**Determining peach and tomato maturity and quality with non-destructive light scattering.**

Non-destructive light wavelengths can be used to assess the maturity of horticultural products and help producers deliver superior, consistent products to the market to meet or exceed consumer expectations. ARS researchers in East Lansing, Michigan, measured the spectral-scattering of peaches and tomatoes harvested at different maturities. These data were combined with destructive measurements of maturity (color, firmness, and soluble solids content) to develop calibration models that predict maturity and quality grades. Good predictions (around 90%) of firmness and soluble solids content were achieved for these fruits. (Project No. 3635-43640-001-00D)

**The environment selectively affects sorghum quality factors.**

Sorghum, the ancient, gluten-free grain, is known for its dietary health benefits in combating cancer, diabetes, and cholesterol. It consists of starches, proteins, and fats, which along with grain hardness, influences the products that can be produced from it. ARS researchers in Manhattan, Kansas, along with collaborators at Texas A&M University, discovered that sorghum protein content and quality were more influenced by genetics; whereas kernel hardness, starch content, starch graininess, and fat content were influenced by the environment. This research will help identify grain quality traits that can be iNP. (Project No. 5430-44000-023-00D)



## ANIMAL PRODUCTION AND PROTECTION

### National Programs:

- **Animal Health, NP 103**
- **Food Animal Production, NP 101**
- **Aquaculture, NP 106**
- **Veterinary, Medical, and Urban Entomology, NP 104**

### **Cytokines as an alternative to antibiotics to prevent and combat infectious disease.**

The use of cytokines, small proteins that are important in cell signaling and that affect the behavior of other cells, to stimulate the immune system as alternatives to antibiotics is a promising area for biotherapeutic use to prevent and combat infectious disease. ARS scientists in Ames, Iowa, investigated the potential value of using the granulocyte colony stimulating factor (G-CSF) as a potential alternative to antibiotics in food animal production for controlling pathogenic bacteria in which neutrophils (white blood cells that are the first line of defense against bacterial infections) can provide protection. G-CSF enhances the production and release of neutrophils from bone marrow and is already licensed for use in humans. A limitation of cytokines is their short half-life, which may limit their usefulness as a one-time injectable in production animal medicine. The scientists found that the administration of recombinant G-CSF induced a transient increase in neutrophils (neutrophilia) in pigs, however, delivery of porcine G-CSF inserted in a replication defective adenovirus (Ad5) vector significantly increased the effect of neutrophilia. Pigs given one injection of the Ad5-G-CSF had a neutrophilia that peaked between 3 to 11 days post-treatment and neutrophil counts remained elevated for more than 2 weeks. Neutrophils from Ad5-G-CSF treated pigs were fully functional based on laboratory tests, demonstrating that G-CSF may be an effective alternative to antibiotics for treating bacterial pathogens susceptible to neutrophils. (Project No. 3625-32000-108-00D)

### **Vaccinating against intestinal parasites.**

Controlling parasites in production animals is difficult because parasites produce proteins that alter and suppress the host's immune responses, which improves the odds for parasite's survival. ARS scientists in Beltsville, Maryland, used a recombinant protein against the parasite *Ostertagia* to vaccinate a group of animals which then developed a high degree of protection against parasite infection and damage. Future studies on larger number of animals are being planned, and additional potential vaccine candidates have also been identified. Since some medications are becoming increasingly ineffective at controlling parasites, developing vaccines will provide producers with another option for protecting livestock health. (Project No. 1245-32000-096-00D)

**Amino acid changes in a viral protein determine the evolution of swine influenza A H3N2 viruses.**

Swine influenza A virus is an endemic and economically important pathogen in pigs with the potential to infect other host species, including humans. Pigs may also become infected with human influenza A viruses. The viral hemagglutinin (HA) protein binds viruses to cells and is the primary target of protective immune responses and the major component in swine influenza A vaccines. However, as a result of genetic mutations known as antigenic drift, vaccine virus strains must be regularly updated to reflect currently circulating strains. Characterizing how different virus strains in pigs are to the seasonal influenza virus strains in humans is important in assessing the relative risk of interspecies transmission. ARS scientists in Ames, Iowa, found that two primary swine influenza virus strains are currently circulating in the U.S. pig population, but with enough diversity between the HA proteins to suggest updates in vaccine strains are needed. The scientists identified specific changes in the HA protein that are likely responsible for differences between the two viruses. The differences between current seasonal influenza H3N2 strains in humans and those endemic in swine is enough that population immunity is unlikely to prevent the introduction of human viruses into pigs and vice versa, reinforcing the need to continuously monitor and prepare for influenza A viruses in both species. (Project No. 3625-32000-108-00D)

**Potential virulence factor of Asian highly pathogenic porcine reproductive and respiratory syndrome virus.**

Asian highly pathogenic porcine reproductive and respiratory syndrome virus (HP-PRRSV) is not currently known to infect U.S. livestock, but it nevertheless poses a serious potential threat to the nation's swine and agricultural economy. HP-PRRSV causes more severe disease than PRRSV strains circulating in the United States, but it is not known why. ARS scientists in Ames, Iowa, in collaboration with scientists at the University of Denver, examined the activity of a small part of a viral protein called a protease, which is an enzyme that breaks down proteins. The scientists found that the HP-PRRSV region of this protease was 40 times more capable of breaking apart specific types of a cellular protein called ubiquitin than a U.S. strain of PRRSV that causes only mild disease in pigs. Ubiquitin has been implicated in the regulation of many cellular processes, including immune response controls. The actions of this small part of the viral protein of HP-PRRSV may correlate with the increased disease and may serve as a target in vaccine development. (Project No. 3625-32000-108-00D)

**Virulence genes associated with *Haemophilus parasuis* infection.**

*Haemophilus parasuis* causes Glasser's disease in pigs, and results in chronic debilitation and death. There is currently no effective vaccine for the disease, which costs the swine industry millions annually. ARS scientists in Ames, Iowa, who had previously identified 10 strains of *H. parasuis* with differing levels of virulence, recently sequenced these 10 strains and identified genes in some strains that may be associated with virulence and disease. These discoveries can help support the development of vaccines that may be effective against this costly pathogen. (Project No. 3625-32000109-00D)

**Improving the reproductively competent pool of females in swine.**

Although significant advancements have been made in swine production, better reproduction processes, specifically the identification of newborn females that will be reproductively competent in adulthood, have lagged behind. Previous reports have indicated that a newborn piglet's environment can affect its growth, body composition, and reproductive potential as an adult female pig. In an experiment funded by the National Pork Board, ARS scientists in Clay Center, Nebraska, in collaboration with scientists at Iowa State University and Murphy Brown LLC, identified three criteria that collectively could be used to determine a delay in puberty, increased puberty failure, and detrimental changes in the uterus. Incorporation of measurements for these criteria in the production setting could be used for early selection of female pigs destined for the breeding herd. (Project No. 5438-31000-091-00D)

**Defining genetic determinants to select for superior resistance to Marek's disease in poultry.**

Marek's disease is an extremely contagious viral disease that is capable of causing major losses of chicken, one of the largest agricultural animal commodities in the United States. The disease is currently controlled through vaccines and biosecurity, but enhancing genetic resistance to it would be a more effective mode of disease control. ARS scientists in East Lansing, Michigan, in collaboration with scientists at Purdue University,

demonstrated that a subset of previously identified genetic markers of Marek's disease. Measuring the marker-gene association had higher accuracy (61 percent improvement) in identifying birds with superior genetic resistance compared with current state-of-the-art methods. If confirmed in commercial poultry lines, this approach could efficiently select for elite, healthy poultry to generate more economical poultry products for U.S. producers and consumers. The model may also have application in addressing genetic resistance to other infectious pathogens. (Project No. 3635-31320-009-00D)

**A much more productive wool ewe.**

Maximizing the number of successful pregnancies and the live birth of healthy offspring is important for sheep farmers. Over a lifetime, ewes that lamb for the first time at 1 year of age are more productive than ewes that lamb for the first time at age 2, but wool producers are reluctant to adopt this strategy because of the low rate of pregnancy in wool-type ewes younger than 1 year. ARS researchers in Dubois, Idaho, with cooperators at Virginia Tech University, developed a genetic-based measurement to establish the rate of pregnancy in a wool breed and identified rams with specific genetic backgrounds that yield a greater number of daughters that lambed as 1-year-olds compared with the flock average. These measurements will enable wool sheep producers to select specific rams for breeding and improve overall production efficiency by the gain of an additional year of productivity in a greater number of ewes. (Project No. 5364-31000011-00D)

**The sheep genome illuminates the biology of the rumen.**

Sheep (*Ovis aries*), which are a major source of meat, milk, and fiber (wool), have a specialized digestive organ called the rumen that carries out the initial digestion of plant material. An ARS scientist in Pullman, Washington, participated in the International Sheep Genomics Consortium that included participants from a number of laboratories from around the world. The consortium assembled the sheep genome for the first time and used a large amount of gene expression data from 40 different tissues to show where different genes are located on the chromosomes and where these genes are active. This information was used to investigate several unique *Ovis aries* traits, including assessing how sheep process low quality forage into high-quality animal protein. The project provides a reference sheep genome assembly that will form the basis of future research into all aspects of sheep biology, including susceptibility to infectious disease, which will benefit U.S. sheep producers. (Project No. 5348-32000-031-00D)

**First validated genetic marker test for post-infection control of ovine progressive pneumonia virus.**

Ovine progressive pneumonia virus is a small ruminant virus that causes long-term and progressively worsening pneumonia and mastitis in domestic sheep. Some sheep have genetic traits that provide protection from more serious infections, but no tests have been available to identify animals with this more robust immune response. ARS scientists in Pullman, Washington, and Dubois, Idaho, in collaboration with Washington State University, demonstrated that sheep with two copies of a small deletion near the ZNF389 gene were able to control viral replication, which lessened the severity of their infection. This result was observed in multiple sheep flocks under widely differing management and viral load conditions and is the first validated genetic marker test for postinfection control of ovine progressive pneumonia virus. Results from this study will help animal breeders develop varieties of sheep that are more resilient to viral infection. (Project No. 534832000-031-00D) 348-32000-031-00D)

**Selection to reduce ovine progressive pneumonia.**

Ovine progressive pneumonia, a viral disease, is one of the most costly sheep diseases in North America and management schemes to minimize and eliminate the prevalence of this disease are labor-intensive and expensive. ARS researchers in Clay Center, Nebraska, demonstrated that sheep with an unfavorable form of the gene associated with susceptibility to ovine progressive pneumonia had a much higher rate of infection compared with sheep that lacked that form of the gene. The scientists developed technology to identify animals with the high-risk gene so that sheep producers can now selectively breed and generate flocks that are genetically less susceptible to ovine progressive pneumonia. This should enhance the health of sheep flocks and increase economic profits for producers. (Project No. 5438-31000-09000D)

**Old tool finds new use in reducing nitrogen emissions from dairy farms.**

Nitrogen is a key component of protein in the diet ration for dairy cattle. Maximum absorption of protein in the gut is crucial to avoiding the excretion of excessive nitrogen-containing compounds that may constitute greenhouse gases, affect air quality, and ultimately, human health and natural ecosystems. ARS scientists in Madison, Wisconsin, studied the use of milk urea nitrogen, a common tool applied to monitor feed efficiency in dairy herds, to evaluate the relationships between the amount of protein fed to lactating cows, nitrogen compounds in milk, and excreted nitrogen on dairy farms. A high correlation was found between milk urea nitrogen values and excreted nitrogen values. The findings demonstrated that monitoring of milk urea nitrogen on dairy farms can be used to optimize protein use in dietary rations that will reduce feed costs for dairy cows and negative effects to the environment. (Project No. 3655-31000-023-00D)

**Yeast supplementation improves the well-being of stressed calves.**

Management livestock management practices do not always provide optimal protection from disease. One of the most stressful times in the life cycle of a calf is removal from its mother and shipment to a feedlot where it mingles with other unfamiliar calves, and the resulting stress increases the incidence of disease. Identification of feed supplements to ensure health, growth, and overall well-being is of benefit to livestock producers. ARS scientists in Lubbock, Texas, with colleagues at the University of Nebraska, determined that feeding a yeast supplement to calves that fail to grow or develop normally as a consequence of disease improved both the calves' health and growth. Yeast may prove to be a beneficial, antibiotic free supplement for the livestock industry to manage calves with the highest risk for becoming ill. (Project No. 6208-32000-007-00D)

**Feeding a by-product of ethanol to cattle maintains nutrient value and reduces production cost.**

Dietary fiber in diets given to cattle in feedlots promotes good digestion; however, fiber is the costly portion of the diet. ARS researchers in Clay Center, Nebraska, determined that adding an ethanol by-product, wet distillers grains with solubles, and reducing the amount of fiber before cattle go to market, increases the retention of nutrients. These studies demonstrate that wet distillers grains with solubles can be used to reduce the cost of feed and production expenses, and improves the types of nutrients available to cattle. (Project No.5438-31000-092-00D)

**Improved computer-assisted modeling of genetic traits to enhance milk production efficiency.**

Milk production, one of the largest agricultural animal-based commodities in the United States, is dependent on successful pregnancies and calving. Fertility rates in Holstein cattle, the primary dairy breed in the United States, had been declining until recently; this has increased the cost of milk. To improve the prediction of fertility in dairy cattle, ARS scientists in Beltsville, Maryland, have developed computer models from extensive data sets going back to the 1960s that go beyond the previous single-trait, single-breed model to incorporate multiple traits, multiple breeds, inclusive of crossbreds and purebreds, and environment to more accurately predict the effect of genetic backgrounds associated with fertility. The new model correlated well with the previous model for Holsteins. Data were combined and implemented by ARS and the Council on Dairy Cattle Breeding in December 2013 to improve genetic evaluations for fertility. The past model reversed the fertility drop, and the inclusion of the new model is expected to improve the accuracy of predictions of genetic merit for fertility traits and allow breeders to make faster progress. (Project No. 1245 -3100-101-00D)

**Identification of biomarkers for early diagnosis of *Mycobacterium bovis*.**

*Mycobacterium bovis* is the primary pathogen that causes bovine tuberculosis in cattle, a disease that can also be transmitted to humans. Though a program to eradicate bovine tuberculosis began in 1917, eradication efforts are still continuing. Diagnosing bovine tuberculosis remains problematic, especially in the early stages of the disease, but recent work by ARS scientists in Ames, Iowa, resulted in the identification of several potential biomarkers in the blood of infected cattle that may enable more accurate diagnosis. The development of effective blood tests for bovine tuberculosis will make disease detection easier and may support its eventual eradication. (Project No.3625-32000-10400D)

**Mutations conferring heat tolerance in cattle identified.**

With global climate change and increasing demands for animal protein worldwide, there is a need to understand and accelerate the adaptation of agricultural animals to the environment. Cattle breeds in subtropical and tropical regions maintain a stable internal deep body temperature that is indicative of a genetic predisposition toward heat tolerance, however, variations in heat tolerance are evident among different tropical breeds. ARS scientists in Beltsville, Maryland, in collaboration with scientists at U.S. and foreign universities, identified distinct mutations in genes regulating skin formation, hair growth, and cooler body temperature that are inherited in heat-tolerant breeds. Results from the study are being used by producers to guide future breeding decisions, and by researchers to better understand the biological processes involved in adaptation to climate change. (Project No. 1245 -3100-104-00D)

**Enhancement of the beef carcass grading camera system to predict meat tenderness.**

Variation in the tenderness of beef results in consumer dissatisfaction; therefore, companies want technology to identify carcasses that excel in tenderness. ARS scientists in Clay Center, Nebraska, worked with the instrument manufacturer and the beef industry to develop a robust regression equation for the system, which has obtained approval from USDA's Agricultural Marketing Service to predict tenderness at the time of beef carcass grading. The technology gives the beef industry a way to measure USDA quality grade, yield based on grade, and tenderness with the same instrument; application has been instituted in one packing plant, and other plants are considering it. This new system is expected to offer consumers a better way to select higher-quality meat. (Project No. 543831430-005-00D)

**New processing method to improve nutritional value of ethanol production co-products.**

The primary method for producing fuel ethanol from grains results in a co-product known as distiller's dried grains with solubles (DDGS), which is a low-value ingredient for animal feeds. The standard method results in distiller's grains of high fiber and low protein digestibility, and only a single product being produced. These problems reduce the total revenue from ethanol production and limit the use of the co-product in animal feeds. To improve the value of this co-product, ARS scientists in Aberdeen, Idaho, determined the fate of many nutrients during traditional processing and devised a new method to recover multiple co-products, including a high-protein feed ingredient, a high-ash fraction for mineral supplementation, an oil fraction, and a glycerol fraction. Greater value of co-products from ethanol production increases the value generated by using renewable energy and provides valuable nutrients for animal production. (Project No. 366-21310-004-00D)

**Development of a vaccination platform to protect catfish against *Enteric septicemia*.** *Enteric septicemia* is the most devastating disease affecting the catfish industry. The development of a new vaccine and feed-based delivery platform has resulted in providing exceptional protection against enteric septicemia of catfish with dramatic increases in production efficiency and economic returns. Mississippi State University scientists working in collaboration with ARS scientists developed a mechanized vaccine delivery system that consistently delivered target-immunizing doses in experimental pond trials. The vaccine delivery system was used in commercial field trials during the 2013 production season with excellent results; 2014 production season trials are ongoing. This vaccine will support catfish producers in efforts to control diseases and manage production costs. (Project No. 6402-31320-002-00D)

**Effective vaccine candidates to prevent *Aeromonas* disease in catfish.** From 2009 to the present, outbreaks of motile aeromonad septicemia (MAS) in market-size catfish have occurred in western Alabama and eastern Mississippi with losses estimated to be greater than \$12 million. Currently, there are no methods available, such as vaccination, to prevent MAS, but they are urgently needed. ARS scientists in Auburn, Alabama, identified secreted extracellular proteins of the bacterium that trigger protective immune responses. Their results show that catfish immunized with the extracellular proteins are resistant to infection and that this immunity persisted for at least 7 weeks. This research provides the foundation for developing an effective vaccine to prevent MAS disease and may help catfish producers contain production losses. Project No. 6420-32000-024-00D)

**Improvement of catfish growth.**

Producers and processors of farm-raised catfish would like to improve catfish growth. ARS scientists at the Warmwater Aquaculture Research Unit in Stoneville, Mississippi, have conducted a selective breeding program over several catfish generations to improve this trait, and showed that catfish in the breeding program were more than 25 percent larger at harvest than catfish that were not in the breeding program. These efforts are part of a long-term breeding program to improve channel catfish germplasm for release to the United States catfish industry. (Project No. 6402-31000-009-00D)

**Method to produce a protein concentrate from barley is commercialized for aquaculture.**

Feeds costs are a significant production item in commercial aquaculture. Barley that is too high in protein to be used for malting has the potential to be developed as a protein-based fish feed. A method was developed and patented by ARS scientists in Aberdeen, Idaho, for producing a protein concentrate that can be incorporated into aquaculture feeds. Feeding studies with rainbow trout and Atlantic salmon demonstrated the concentrate is highly digestible and supports rapid fish growth, reducing the need for more expensive ingredients such as fishmeal. A pilot plant for barley concentrate production has been built and is delivering the product to commercial farms in Idaho. Two more plants are in development. (Project No. 5366-21310-004-00D)

**The development of a new tool to speed genetic improvement in rainbow trout.** Technology to use genomic information for improving selective breeding in dairy cattle and poultry has not yet been developed for rainbow trout. ARS researchers at the National Center for Cool and Cold Water Aquaculture in Leetown, West Virginia, worked with international partners to develop a commercially available genetic marker tool (SNP chip) for rainbow trout. By incorporating genome information, this tool improves performance prediction accuracy for individual fish versus traditional family-based estimates. Commercial producers will find this information useful and it will likely accelerate genetic improvements in trout. (Project No. 1930-31000-009-00D)

**Atlantic salmon evaluated and selected for multiple traits.**

Commercial salmon producers in the United States use stocks that are not many generations removed from wild, unselected stocks. Because salmon are an endangered species, producers are legally required to culture certified stocks of North American salmon. ARS researchers at the National Cold Water Marine Aquaculture Center in Franklin, Maine, in collaboration with industry, generated a broodstock of fish with North American origin and compared the growth of 4-year classes of salmon from their breeding program with a control line of fish in commercial sea cages. Salmon that were selected for greater growth, resistance to sea lice, and better fillet color, averaged approximately 90 percent larger than the control fish. Using improved salmon germplasm is increasing the cost-effectiveness, profitability, and sustainability of cold water marine aquaculture in the United States and providing a quality seafood product to consumers. (Project No. 1915-31000-003000D)

**Scaling up recirculating aquaculture systems for Atlantic salmon.**

Although production of Atlantic salmon in land-based recirculating water systems offers an environmentally sustainable approach to meeting domestic demands for seafood, some offflavors can develop in such systems, and harvest strategies must be developed that ensure the product quality that consumers expect. Researchers at the Conservation Fund's Freshwater Institute in Shepherdstown, West Virginia, working with an ARS researcher in Oxford, Mississippi, determined that concerns about off-flavor in 4-kg Atlantic salmon can be eliminated with a purging step in which fish are transferred to tank systems pre-disinfected with hydrogen peroxide and that do not contain hard-to-clean locations, such as aeration media, during the final 6-10 days of fish rearing. Compounds associated with off-flavor were consistently reduced to levels that are below human tasting limits. These standard operating practices maximize product quality for Atlantic salmon and other species that have been cultured in water recirculating systems. (Project No. 193031320-001-00D and 6408-41000-009-00D)

**Improving water quality and lowering the price of diets for hybrid striped bass.**

Temperature and ammonia levels (ammonia is a waste product secreted by fish) often increase dramatically in ponds during summer production of hybrid striped bass in the southern United States. Extended periods of high ammonia result in fish stress, disease, mortality, and significant loss of feeding days as producers attempt to

reduce ammonia to manageable levels by reducing feeding or using lower protein diets. Along with participants from the Trout-Grains Project, ARS scientists in Stuttgart, Arkansas, and Hagerman, Idaho; and U.S. Fish and Wildlife Service scientists in Bozeman, Montana, demonstrated better growth and nutrient retention by hybrid striped bass fed a 35 percent protein diet supplemented with limiting amino acids compared with fish fed a higher protein diet. Overall protein levels were decreased, whereas dietary nutrient retention increased, thereby lowering feed costs to producers and reducing negative environmental effects on water quality. (Project No. 6225-31630-06-00D)

**Minimal impacts of oyster aquaculture to eelgrass at the landscape scale.**

Submerged aquatic vegetation such as eelgrass provides valuable habitat for fish and invertebrates in estuaries, particularly for juvenile salmon on the west coast of the United States. ARS researchers in Newport, Oregon, used layers of geographic information on tidal heights, cumulative wave stress, salinity, distance to the river mouth, and distance to the nearest channel to quantify the distributions of eelgrass and bivalve aquaculture in Willapa Bay, Washington. The effect of bivalve aquaculture on eelgrass at the landscape scale was measured over a period of 5 years. Although oyster harvest methods had demonstrable effects on eelgrass over time at the individual bed scale, oyster aquaculture reduced eelgrass cover by less than 1 percent in any given year over the entire estuary. This information promotes sustainable shellfish culture and is enabling managers and regulators to evaluate the potential effects of existing and expanded oyster aquaculture on estuarine habitat. (Project No. 5358-63000-003-00D)

**Mosquitoes can “taste” repellents such as DEET.**

Mosquitoes transmit a variety of human pathogens, including the malaria parasite and the viruses that cause yellow fever, Dengue fever, and West Nile virus. Understanding more about why particular substances attract or repel mosquitoes could help identify new chemicals that alter mosquito behavior. ARS scientists in Beltsville, Maryland, discovered a taste receptor on the mouthparts of the yellow fever mosquito that is sensitive to the insect repellent DEET and were able to identify the specific hairs at the tip of the mosquito’s mouthparts responsible for repellent detection. This fundamental research finding provides a new method for screening and identifying novel chemicals and repellents that disrupt mosquito feeding behavior, which in turn could reduce the frequency with which mosquitoes transmit pathogens that cause human illness. (Project No.1245-32000-007-00D)

**U.S. mosquitoes to transmit Rift Valley fever virus.**

Rift Valley fever is a potentially fatal viral disease that infects humans and is transmitted by mosquitoes. The virus can also negatively impact livestock health. Though largely restricted to the African continent, experts are concerned that the Rift Valley virus could be introduced and established in the United States. In laboratory studies, ARS scientists in Gainesville, Florida, evaluated eight species of mosquitoes commonly found in the United States for their ability to transmit the Rift Valley fever virus. They found that some species of mosquitoes have a greater ability to transmit the virus than other species, a finding that has a direct impact on the risk assessment of disease transmission to humans and livestock. These results will allow mosquito control assets to target the mosquito species most likely to be involved in disease transmission if Rift valley fever is ever found in the United States. (Project No.6615-32000-045-00D)

**Development of a Rift Valley fever virus challenge model to evaluate vaccines in sheep and goats.**

Rift Valley fever virus (RVFV) is transmitted by mosquitoes and causes severe to fatal disease in ruminants and humans which can be preventable by vaccination. Ruminants are known to amplify RVFV and are a potential source of infection for humans. Availability of a challenge model is a pre-requisite for vaccine efficacy trials. Several modes of inoculation were tested by ARS scientists in Manhattan, Kansas, in collaboration with scientists with the Canadian Food Inspection Agency. Differences in development of infections in sheep and goats were observed between animals inoculated with RVFV produced in mosquito cells compared to mammalian cells. Only RVFV produced in mosquito cells led to development of virus in the blood (viremia) in all inoculated animals. The insect cell produced RVFV appeared to be more infectious with earlier onset of viremia, especially in sheep, and may also more closely represent a field situation. These findings were used to develop a challenge

protocol suitable for evaluating the efficacy of RVF vaccines in sheep and goats. (Project No. 5430-32000-00500D)

**Improved uniforms to protect U.S. military personnel from mosquitoes.**

Throughout much of the world, mosquitoes transmit a wide variety of disease causing agents. U.S. deployed military personnel must rely upon synthetic insecticide sprays to kill blood feeding pests, and/or topical repellents for personal protection. ARS scientists in Gainesville, Florida, are working with the Department of Defense to test the useful life of U.S. Marine Corp and Navy military uniforms impregnated with the insecticide permethrin. The scientists demonstrated that after 50 washings, the treated uniforms still retained their ability to repel biting mosquitoes. This information is essential to protecting U.S. deployed troops from arthropod-borne diseases. (Project No.6615-32000045-00D)

**Occurrence of cattle fever ticks in white-tailed deer.**

Texas cattle fever is a devastating protozoan disease of domestic cattle transmitted by certain types of ticks, termed cattle fever ticks. By 1961, an eradication effort effectively eliminated the ticks and the disease causing pathogen from Texas and the southeastern United States, though a quarantine area along the Texas-Mexico border that is still maintained by Federal personnel as part of the Cattle Fever Tick Eradication Program. Originally, the cattle tick and its parasite was thought to infest only cattle. However, recent evidence has shown that white-tailed deer can also serve as hosts for these ticks. ARS researchers in Kerrville, Texas, in collaboration with scientists from Northern Arizona University, examined the genetic relationships between ticks collected from cattle and ticks collected from deer. They found these ticks to be genetically similar, which explains why tick populations have persisted over time in the quarantine zone. Molecular techniques were also used to determine the invasive potential of ticks into major cattle producing areas in the United States. This information will be useful to scientists and government agencies charged with maintaining tick eradication quarantine areas and maintaining disease free zones in the United States. (Project No.6205-32000-034-00D)

**Reducing the risk of indigenous ticks transmitting equine piroplasmiasis.**

Equine piroplasmiasis was eradicated from the United States in the late 1980s. However, a recent outbreak in Texas caused significant economic loss to the equine industry and suggested that some ticks indigenous to the United States could play a role in transmission. ARS scientists in Pullman, Washington, in collaboration with Texas A&M University, collected and colonized ticks from horses at the Outbreak Ranch. The scientists demonstrated that these indigenous ticks were able to acquire and transmit the parasite to uninfected horses. These results confirm introduction of infected horses into the United States with competent indigenous vectors can result in dissemination of the parasite and thus disease to the nation's equine population. (Project No.5348-32000-034-00D)

**Virus for fire ant control.**

The southern United States has become home to the red imported fire ant, an aggressive and stinging invasive species whose presence costs over \$5 billion annually in livestock and crop losses, pest control, and medical treatment. ARS researchers in Gainesville, Florida, in cooperation with colleagues in Arizona, California, and Illinois, demonstrated that a newly-discovered ant virus only harms fire ants, and does not have a negative impact on other ants that are considered non-target organisms. This research will support the development of a new tool for fire ant control, which could significantly reduce the economic losses associated with the insect and help protect human and livestock health. (Project No.6615-32000-044-00D)

**Genetics of screwworm control.** Infestations with immature screwworms (maggots) devastated the United States livestock industry until a sterile male release technique eradicated screwworms in the 1960s. Sterile insect techniques are still currently used to prevent re-entry of screwworms into the United States. This method requires the mass production, sterilization, and release of millions of sterilized, adult males at a cost of millions of dollars, annually. ARS scientists in Kerrville, Texas, in collaboration with scientists at North Carolina State University, used genetic techniques to produce male only screwworms, making the rearing and release program more efficient and affordable. Maintaining an effective barrier against screwworms re-entering the United States ensures

benefits exceeding \$1.5 billion annually for North American livestock producers. (Project No.6205-32000-035-00D)

**Rearing of immature screwworms.**

The current sterile insect technique used to prevent the re-establishment of screwworms in North America requires the mass production of millions of screwworms. Immature screwworms are raised on maggot food that contains a cellulose fiber bulking agent, but the cellulose fiber additive increases the production of problematic ammonia in the facility. ARS scientists in Kerrville, Texas, and their collaborators in Panama found that ammonia emissions were reduced when the common chemical potassium permanganate was added to the immature screwworm diet. The potassium permanganate also acted as a beneficial anti-microbial agent, which eliminated the need for dietary formaldehyde additives that had been used to prevent bacterial contamination. Reduced ammonia levels in the mass-rearing facilities have improved working conditions for employees and have also improved screwworm quality. This research has resulted in a more cost-effective method of rearing screwworms, which ultimately increases the protection of livestock health and benefits U.S. livestock producers by preventing the re-introduction of this harmful insect pest. (Project No.6205-32000-035-00D)

**Reliable molecular method to distinguish immature screwworms from other immature flies.**

The screwworm is a devastating insect pest of cattle that has been successfully eradicated in the United States, and the rapid and reliable identification of screwworm larvae (maggots) is essential in preventing its reintroduction. However, it is very difficult to distinguish between the different species of fly maggots in their early stages of development. ARS scientists in Kerrville, Texas, collaborated with scientists in Lincoln, Nebraska, to develop a molecular technique for confirming the identity of screwworm maggots in the first few stages of their development. Using this technique, the researchers were able to distinguish between screwworm larvae and the larvae of other closely-related flies that often infest livestock wounds. This molecular approach provides important tools for the screwworm eradication and exclusion program when rapid identification and verification of suspicious larval samples is needed. The technique will eliminate the unnecessary treatment of outbreaks that are not linked to screwworms, which will save thousands of dollars each month. In the case of a real screwworm outbreak, the reliable identification will ensure a rapid response that contains and eliminates the potentially deadly pest and prevent millions of dollars in livestock production losses. The molecular technique developed by ARS scientists will ensure that United States and other North American livestock producers continue to reap the significant benefits (more than \$1.5 billion annually) resulting from screwworm eradication. (Project No.6205-32000-035-00D)

**Identifying biting midges genes involved in feeding, reproduction and viral infection.**

Certain types of biting midges (often referred to as “no-see-ums” or “punkies”) can transmit numerous viruses that cause disease in livestock and wildlife. One of the most serious infections is Bluetongue virus, which is a devastating disease of sheep, cattle, and goats. Because the virus can spread across international borders, U.S. cattle and sheep producers lose \$125 million annually from lost trade and expenses associated with certifying their animals are virus-free. ARS scientists in Manhattan, Kansas, in collaboration with the Clemson University Genomics Institute, have catalogued genes involved in midge feeding and reproduction and have identified genetic traits of virus-infected midges. This research contributes to developing new control strategies for biting midges, and to a better understanding of how to block virus transmissions from infected midges. The information generated by this research will be of value to scientists, livestock producers, and regulatory personnel interested in mitigating the impact of midge-borne diseases. (Project No.5430-32000-003-00D)



## ENVIRONMENTAL STEWARDSHIP

### National Programs:

- **Agricultural System Competitiveness and Sustainability, NP 216**
- **Water Availability and Watershed Management, NP 211**
- **Climate Change, Soils, and Emissions, NP 212**
- **Pasture, Forage and Rangeland Systems, NP 215**
- **Bio-refining, NP 213**
- **Agricultural and Industrial Products, NP 214**

### **Operational implementation of a global root zone soil moisture monitoring system.**

Soil moisture is a key component of Earth's water cycle that is essential for plant life, affecting global energy flux, and influencing weather and climate. Monitoring the availability of soil moisture in the rooting zone is critical for forecasting variations in agricultural productivity which can affect global food prices and food availability. ARS scientists in Beltsville, Maryland, designed a system to globally estimate the availability of soil moisture in the rooting zone, and produced new worldwide soil moisture maps that reveal how the wetness of the land fluctuates seasonally and with changes in weather. These maps are being given to the public to support a wide range of agricultural and hydrologic applications, from advancing climate models and weather forecasts to improving flood warning systems. USDA Foreign Agricultural Service analysts implemented this system in April 2014 to improve their operational forecasts of global agricultural yield and productivity. These forecasts are critically important to commodity markets, and to decision-makers who must depend on crop production information to plan for disasters such as drought, which can lead to food deficits in countries that may require food assistance. (Project No. 1245-13610-028-00D)

### **Mitigating phosphorus loss to ensure the availability of safe drinking water.**

The midwestern United States has some of the most productive agricultural soils in the world, but because of its climate much of this region would be unable to support agriculture without drainage; high water tables would both damage crops and prevent the access of machinery in the fields at critical times. While drainage is designed to remove excess water as quickly as possible, it can also provide a conduit for the rapid loss of agrochemicals, particularly phosphorus that can subsequently degrade the quality of key drinking water supplies. ARS scientists in West Lafayette, Indiana, used a combination of field and modeling investigations to provide information on how to mitigate phosphorus losses from tile drained croplands in conservation tillage. As researchers, policy-makers, and farmers search for ways to reduce phosphorus loadings to surface waters such as Lake Erie, these

studies highlight the importance of treating both surface runoff and tile drainage to minimize harmful algal blooms. (Project No. 3604-13000-011-00D)

**Publication of a 50+ year data record for the Upper Washita River Watershed.**

Sustainable agricultural systems can vary significantly because the combined factors of weather, water, topography, soils, vegetation, space, and time differ from site to site and in turn significantly affect management decisions. Nevertheless, site-specific, long-term studies can help producers develop general principles to manage sustainable systems and anticipate the risks and possible outcomes of various scenarios associated with climate changes, market swings, and policy shifts. ARS researchers in El Reno, Oklahoma, with their collaborators from the U.S. Geological Survey and USDA Natural Resources Conservation Service, published a collection of data and research papers describing long-term research (1961 to present) in Oklahoma's Upper Washita River basin. This living history of research is presented to encourage scientists from different institutions and disciplines to collaborate on studies of complex, interactive processes and systems. These processes and systems include increasing resilience to current and future climate pressures; watershed-scale studies on contaminant sources, fates, and transport; hydrologic cycles, including their links through space and time; and developing decision-making protocols that consider how individual farm management can affect watershed-scale outcomes, and vice versa. As climate patterns shift, information from this long-term study will help producers in similar regions develop more cost-effective management decisions for optimizing water use and maximizing crop production. (Project No. 6218-13000011-00D)

**U.S. grassland mortality increased following early 21st-century drought.**

In order to manage current and future rangelands effectively, ranchers and land managers in the southwest United States need information about how shifting climate patterns affect the establishment and growth of vegetation in a healthy ecosystem. ARS researchers in Tucson, Arizona, conducted a site study in six USDA experimental grasslands in Arizona, Colorado, New Mexico, Oklahoma, and Utah that measured surface soil moisture and precipitation and compared these measurements with satellite estimates of above-ground plant production. In this study—the first report of how U.S. grasslands may respond to the regional drying and warming predicted with climate change—the researchers found that the early 21st-century drought was followed by a drastic decline in grassland growth, and that native grasses were displaced by less-nutritious and more fire-prone invasive grasses. These findings suggest that changing vegetation patterns can serve as an early indicator of climate change and provide ranchers with new information for managing grasslands to lower fire risk, minimize forage loss, and protect ecosystems in the face of climate change. These regional-scale field studies can significantly support future grassland research, management, and policy and help identify cost-effective decisions that protect rangeland ecosystems for livestock production and recreation. (Project No. 5342-13610-011-00D)

**A new model, iSnobal, for managing snowmelt in the western United States.**

Water supplies from western mountainous watersheds are in extremely high demand for agricultural production, clean electricity, and domestic uses. To optimize water supply management, traditional methods of stream flow forecasting must be improved. ARS scientists in Boise, Idaho, developed a new more sophisticated model, iSnobal, which goes beyond simple empirical relationships, but has not been used for management purposes due to its high computational demands and the expertise required to simulate snow accumulation and melt patterns over large areas. Over the past year, ARS scientists successfully integrated the iSnobal model into the U.S. Bureau of Reclamation's forecasting procedures for the 2,500 square mile Boise River Basin in Idaho. Also, weekly updates of snow cover density over a large region of the southern Sierra Nevada Mountains are now being provided for NASA's Alpine Snow Observatory program. This represents a major change in the commitment of western water managers toward using more sophisticated process-based modeling in their future river forecasting programs. (Project No. 5362-13610-010-00D)

**Controlling atrazine losses in agricultural watersheds underlain by restrictive layer (clay pan) soils.**

Atrazine is one of the most prevalent soil applied herbicides used in corn cultivation. Its widespread use has led to significant contamination of surface and ground water resources across the U.S. Corn Belt. Restricted layer (clay pan) soils in northeastern Missouri are particularly vulnerable to the transport of both soil and atrazine in

surface runoff. To find ways of controlling atrazine losses in these landscapes, a team of ARS scientists in Columbia Missouri, assembled 15 years of data from the 28 square mile Goodwater Creek Experimental Watershed. Researchers from this team isolated and confirmed the identity of an atrazine degrading compound (DIBOA-Glc) from eastern gamagrass that could lead to the development of a commercial product to enhance atrazine degradation in soils. The team also found that a commercially available tillage implement (a rotary harrow) substantially reduced atrazine loss, but did not significantly increase erosion compared to no-till. This research provides key information on atrazine movement, particularly in restricted drainage soils, thus providing mechanisms to help farmers both enhance atrazine degradation and prevent its loss in runoff, while simultaneously maintaining the erosion control benefits of reduced tillage. These findings have the potential to greatly improve the region's most persistent water quality problems, improving the sustainability of crop production while maintaining or increasing farmer profitability. (Project No. 3622-12130-005-00D)

**Elevated carbon dioxide (CO<sub>2</sub>) further lengthens growing season under warming conditions.**

Rangeland forage levels are changing because of climate warming, and more information is needed about these dynamics so that management practices can be adjusted appropriately. In collaboration with Colorado State University researchers, ARS scientists in Fort Collins, Colorado, used a Free-Air CO<sub>2</sub> Enrichment (FACE) system to study how elevated carbon dioxide (CO<sub>2</sub>) and temperature affected the growing season for temperate grasses. FACE uses outdoor heaters and pipes in experimental fields to elevate air temperature and CO<sub>2</sub> levels. Warming led to a longer growing season, because leaves emerged earlier in some plants and other plants died later in the season. Elevated CO<sub>2</sub> levels also reduced plant water demand—a response that extended the growing season, but did not change the reproductive season—which in turn increased plant life span. These results will improve the accuracy of models used to simulate plant growth and watershed changes under current and projected elevated CO<sub>2</sub> concentrations and warming. The improved models, in turn, will help producers, rangeland managers, and others to generate appropriate management practices that incorporate ecosystem shifts associated with climate change. (Project No. 5402-13660-008-00D)

**Cropping system impacts on nutrient concentrations in soil water.**

When fertilizers are applied to Midwestern row crops, some of the phosphorus and nitrate is lost from the soil and pollutes nearby waterways. Sometimes these nutrients are eventually transported to large estuaries or lakes, where they help create oxygen-deficient “dead zones,” so their loss from fields has both environmental and economic costs. Since nitrate losses beneath perennial crops such as alfalfa are known to be small, an ARS scientist in Ames, Iowa conducted an investigation to see if nutrient losses associated with annual row crops in the Midwest could be reduced through changes in cropping systems. The scientist collaborated with Iowa State University researchers in an 8-year study to compare nutrient concentrations in soil water beneath different cropping rotations. Their results indicated that growing alfalfa and corn (an annual crop) in rotation can reduce phosphorus losses, and that 4-year rotations are the most feasible management option for farms that integrate crop and livestock production. These findings, which can be used to help moderate nitrogen and phosphorus losses from crop fields and optimize management practices, will benefit agricultural and conservation communities alike. (Project No. 3625-13000-01000D)

**Multiple combined best management practices reduce sediments and increase lake water clarity.**

As ARS scientists in Oxford, Mississippi, identify agricultural best management practices (BMPs) that improve water quality, they need to determine how effective these practices are within an entire watershed. To answer these questions, they conducted a study that measured water clarity, total suspended sediment, and total dissolved solids in Beasley Lake—a Conservation Evaluation Assessment Project watershed in the Mississippi Delta—from 1996 to 2009. Their results indicated that a variety of BMPs in the watershed over the 14-year project resulted in improved water clarity and reduced levels of suspended sediments and dissolved solids, most notably during the spring. All helped to regenerate a healthy and sustainable lake ecosystem. These findings will guide regulatory agencies, farming stakeholders, and other groups in selecting effective conservation practices that improve and sustain lake and floodplain water quality and enhance the overall environment. (Project No. 640813660-007-00D)

**Climate impacts on agricultural crops assessed for the Midwest.**

Regional baseline assessments of crop vulnerability to regional climate changes are needed to provide a foundation for developing adaptation strategies. As part of the Midwest Climate Change Hub activities hosted by ARS in Ames, Iowa, climate impacts on annual grain crops, specialty crops, and perennial crops were evaluated across the Midwest. Soil water availability was found to be the most significant factor affecting production in the Midwest. Additionally, the findings showed that within season weather effects on annual production depend on when stress is imposed. Corn and soybean are more tolerant of stress conditions during the vegetative stage than the reproductive stage. Vegetables are affected throughout their growth cycle by weather variations that affect insect pest populations and plant diseases. Perennial crops are affected early in the growing season by below normal temperatures, and late in the growing season by temperature and water stress. These findings indicate that practices that increase soil water storage capacity can help cropping systems become more resilient to climate-related variables during the growing season, and provide guidance for strategies to develop climate smart crop varieties and management systems. (Project No.3625-11610-001-00D)

**Determination of the “upper lethal growing season average air temperature” for wheat.**

Adapting wheat production to conditions associated with climate change will require determining how higher air temperatures affect wheat and incorporating this knowledge into growth models. ARS scientists in Maricopa, Arizona, in collaboration with scientists at the University of Arizona in Tucson, conducted a “Hot Serial Cereal Experiment.” On six planting dates for the experimental wheat crops, infrared heaters were deployed above some of the plots to provide additional warming. Results showed that yields decreased as season average air temperatures increased above 15°C, and that crops failed once temperatures reached 32°C. These results provide much needed information on the environmental limits for wheat production and will serve as a benchmark for researchers developing new varieties and new management strategies for adapting wheat to the higher air temperature resulting from global change. This research also provides more realistic projections of future climate change effects on wheat, and data for the Agricultural Modeling Intercomparison and Improvement Project. (Project No. 5347-11000-01000D)

**Corn stover harvest effects on nutrient concentrations in central Iowa.**

Proponents of cellulosic biofuel need to understand how soil nutrient levels will be affected by removing corn stover for use as feedstock for cellulosic biofuel. More than 500 site-years of corn plant samples were collected by ARS scientists in Ames, Iowa, who divided plant samples into different parts (stems, leaves, and grain). All samples were analyzed to determine nutrient concentrations. The results showed that compared to harvesting only the grain, harvesting corn stover increased nitrogen, phosphorus, and potassium loss by 14, 1.4, and 16 pounds per ton, respectively. The losses of nitrogen and phosphorus are not considered enough to change current nitrogen and phosphorus fertilization practices for stover harvest rates of one ton/acre. However, the potassium loss is sufficiently high to warrant routine soil testing and plant analysis to monitor available potassium levels. This information provides guidelines for the acquisition of sufficient feedstock supplies to operate emerging cellulosic biofuel investments in a sustainable manner. (Project No.3625-12000-013-00D)

**Conservation farming mitigates erosion impacts from extreme rainfall events.**

Although conservation farming practices have substantially reduced erosion and sediment loss, these benefits may be threatened by more frequent high intensity rainfall events. ARS scientists in Tifton, Georgia, evaluated runoff and sediment loss from conventionally tilled (CT) and conservation strip tilled (ST) fields in a Southern Atlantic Coastal Plain landscape during a 10 year rotational cotton peanut production with a rye winter cover crop. Over the 10 years, the mean annual amount of solid material transported by runoff was 87 percent higher in CT fields than in ST fields. Total runoff from ST fields was 41 percent less than total runoff from the CT fields. The maximum rate of annual soil erosion that still enables continued crop production, known as the soil tolerance value, was exceeded in 3 out of 10 years by CT, but was never exceeded by ST. Extreme rainfall events accounted for 61 to 72 percent of the CT system sediment load and 73 to 84 percent of the ST system sediment load. These results demonstrate that ST management is less susceptible to sediment loss from extreme events than CT systems, and that ST systems are still more effective at reducing sediment loss in this landscape than CT systems. More specifically, the results point to the continued use of cover crops and strip tillage as essential best

management practices as the frequency of high intensity rainfall events increases. (Project No. 6602-11130-003-00D)

**Inoculation with arbuscular mycorrhizal (AM) fungi increases sweet potato yields.**

Alternative crop nutrient management strategies are needed to increase production, cut production costs, and reduce the loss of agrochemicals to the environment. Plants and arbuscular mycorrhizal (AM) fungi often have a mutually beneficial relationship; the host plant supports AM colonies, and the fungi improve the plant's uptake of nutrients and water. ARS researchers in Wyndmoor, Pennsylvania, found that sweet potato yields increased 10 percent after an AM fungus product was placed directly into the planting hole in the field, or when the plants were first grown in an AM-amended potting mix in a greenhouse. Amending soils with this type of AM product could benefit vegetable producers by enhancing plant nutrient uptake, reducing the need for fertilizer applications, increasing yields, reducing the risk of fertilizer losses to the environment, and reducing farm input costs. (Project No. 193512000-011-00D)

**No-till management improves crop yields, reduces environmental risk, and lowers production costs.**

Crop producers are looking for ways to streamline management, reduce inputs, increase cost-effectiveness, and enhance their overall environmental sustainability. ARS scientists in Brookings, South Dakota, compared a no-till production system to a conventional tillage-based system for 6 years and found that no-till production required 20 to 30 percent less water, seed, fertilizer, and herbicide—and produced yields that were 6 percent higher than the conventional system. These results suggest that no-till corn production offers options for farmers to use crop inputs more efficiently, which helps boost profits, reduce environmental impacts, and improve overall production sustainability. (Project No. 5447-12620-003-00D)

**Biochar amended soils can reduce pathogen leaching from livestock into groundwater.**

Pathogens can pose a public health risk when they leach into groundwater. ARS researchers in Bowling Green, Kentucky, investigated whether amending different types of soils with biochar altered soil textures and surface properties and if these changes affected the transport of two pathogenic bacteria through the soil. They found sandy soils amended with biochar retained the largest amount of pathogens. Biochars have already been proposed as a tool for sequestering carbon from the atmosphere and reducing the loss of agrochemicals from the soil. This work suggests that biochar may also reduce pathogen leaching into groundwater. (Project No. 6445-12630-004-00D)

**Improving soils with “designer” biochars.**

Biochars can be added to soils to improve soil quality and crop yields, but yield improvements are not always consistent, perhaps because specific soil deficits are not always improved by biochar amendments. ARS researchers in Florence, South Carolina, and St. Paul, Minnesota, devised guidelines for producing different types of biochars with unique chemical and physical properties suitable for remedying specific soil deficiencies. Results showed that designer biochars were effective at improving soil moisture retention, increasing carbon sequestration, and reducing plant nutrient leaching. Developing guidelines for designer biochars will help U.S. producers use biochars more effectively, increase crop yields, and provide widespread support for management practices that improve soil quality. (Project No. 6657-12130-002-00D)

**New use for animal waste: biochar.** Livestock manure management is often an environmental and economic concern for animal producers. One management option is to convert manures to biochar that can be used for amending soils and improving soil quality, but the processing necessary for wet animal manures requires a high energy input. ARS scientists in Florence, South Carolina, demonstrated that swine manure solids could be blended with plastic mulch wastes to produce both biochar and a combustible gas with heating values higher than natural gas. These efforts demonstrate that pyrolysis technology has the potential to manage two significant agricultural wastes—plastic mulch film and swine solids—while producing biochar and energy. (Project No. 6657-13630005-00D)

**Manure applications benefit soil carbon dynamics in irrigated corn fields.**

Soils store more than three-quarters of the earth's terrestrial carbon, and small changes in agricultural management practices can result in large carbon transfers between the soil and the atmosphere. Because of this, farmers who want to increase soil carbon storage need more information about how storage is affected by field management practices. ARS researchers in Kimberly, Idaho, determined the total carbon budget in an irrigated corn field, including organic and inorganic carbon inputs from the atmosphere, irrigation water, and nutrient amendments (including low-carbon fertilizer or high-carbon dairy manure). Outputs included gas emissions, crop biomass removal, irrigation runoff, and deep percolation. Results showed that although soil carbon gas emissions were 18 percent greater from manure-treated plots, these plots had a net carbon increase at the end of the season, while the plots treated with commercial fertilizer had a net carbon loss. The indirect effect of manure on soil properties, such as aggregate stability, was an important factor that promoted soil retention of manure-supplied carbon. These findings indicate that applying manure fertilizer to irrigated corn could be a promising management strategy for increasing soil carbon storage and improving soil quality. (Project No. 5368-12000-010-00D)

**New amendment to reduce ammonia emissions and phosphorus runoff in poultry manure.**

Two of the biggest sources of pollution from animal manure are excessive ammonia emissions and phosphorus runoff. ARS researchers in Fayetteville, Arkansas, have developed a new manure amendment that greatly reduces both ammonia volatilization and soluble phosphorous levels in manure. An acidified waste product used in forming aluminum sulfate (alum) is alum mud. This waste product is currently placed in landfills at a cost of more than \$30 per wet ton. However, when mixed with bauxite and sulfuric acid, it forms a new manure amendment that works as well as alum in reducing ammonia volatilization and reducing soluble phosphorus, but at half the cost. A patent application covering this technology was submitted to the U.S. Patent Office. If 20 percent of the poultry producers used this technology, it is estimated that \$40 million in savings could be achieved each year while also reducing ammonia emissions and phosphorus runoff from poultry farms. (Project No. 6226-63000-003-00D)

**Phosphate amendments can reduce the uptake of lead from contaminated soils.**

Lead-contaminated soils are a serious hazard to livestock and human health. ARS scientists in Beltsville, Maryland, conducted a 16-year field trial to determine the long-term potential of different soil amendments for reducing lead levels in contaminated soils. These evaluations confirmed phosphate and biosolid compost treatments both significantly reduced the uptake of lead by chemically binding the lead to other compounds. These findings suggest that phosphate amendments can significantly reduce the risk of lead ingestion and can do so much more cost-effectively than managing lead contaminated soils with soil removal and replacement. (Project No. 1245-12000-04000D)

**Identifying areas that can reduce phosphorus loss on dairy farms.**

Loss of phosphorus from runoff on dairy farms can pollute local waters, and it is difficult to identify the areas on a particular site that are most responsible for these losses. ARS scientists in Madison, Wisconsin, monitored phosphorus runoff from cattle pastures and extensively surveyed four pasture-based dairy farms over a multi-year period. Data on runoff and farm management were combined with topographical information to develop advanced computer models to quantify phosphorus loss from a particular site. The research demonstrated that surveys such as this, in combination with new advanced models, can reliably and quickly determine phosphorus loss from runoff and identify those areas in the greatest need of alternative management. (Project No. 3655-12630-003-00D)

**Early warning of unintended discharge from holding ponds.**

Unintentional discharge from feedlot runoff holding ponds can potentially contaminate soil and groundwater. Working with the Nebraska's Cattleman's Association, Nebraska's Department of Environmental Quality, and Agra Tek LLC, ARS scientists in Clay Center, Nebraska, developed an automated resistivity array that can be used as an early warning system of these emissions. The technology allows sub-surface observations and greatly expands the surface area monitored compared with traditional monitoring. The system can notify land managers

via modem or cell phones when a spill occurs, improving response and clean-up times. (Project No. 5438-41630-001-00D)

**Better computer tools to estimate ammonia emissions from beef cattle feed-yards.**

Ammonia losses from cattle feed yards represents both an air pollutant and a loss of nitrogen that could be recycled as a soil amendment. Ammonia emissions will be regulated by the U.S. Environmental Protection Agency in the near future, however, the EPA currently lacks an effective model to determine ammonia emissions or estimate management strategies on ammonia fluxes from agricultural operations. ARS scientists in Bushland, Texas, and State College, Pennsylvania, have improved the Integrated Farm Systems Model to estimate feed-yard ammonia emissions. This model is more accurate than current EPA emission models and has the potential to be adapted by regulators, consultants, and producers to better estimate ammonia emissions and determine the effectiveness of different ammonia management strategies to minimize ammonia losses in feed yards. (Project No. 6209-31630-003-00D)

**Vaccine trials to reduce risk of *Salmonella* in swine.**

*Salmonella* is a leading cause of bacterial foodborne disease. In the United States, more than 50 percent of the swine farms experience *Salmonella* contamination. On-farm interventions are needed to reduce the levels of *Salmonella* in swine production and limit the potential risk of foodborne disease in humans. A rationally attenuated *Salmonella typhimurium* vaccine has been developed by ARS researchers in Ames, Iowa, and is currently undergoing efficacy trials. To date, vaccine trial analysis indicates that swine vaccination reduces disease severity and gastrointestinal colonization due to challenges with both wild type *S. typhimurium* and *S. choleraesuis*. One advantage of the vaccine is that it still allows the use of an industrial test, *Salmonella* lipopolysaccharide, which is used in Europe to monitor *Salmonella* status at the herd level. Consequently, the new vaccine can still be used to differentiate infected from vaccinated animals. (Project No.3625-31000-004-00D)

**Tools and techniques for multi-scale inventory, monitoring, and assessment of western range lands.**

Standardized approaches are needed to monitor range lands that enable agencies to share data and address policy needs. ARS scientists in Las Cruces, New Mexico, led in the implementation of ARS developed core land monitoring indicators, field methods, and sample design techniques within the Bureau of Land Management (BLM), which included its national guidance for monitoring solar and oil/gas development impacts and sage grouse habitat. In addition, ARS led in the integration of BLM's monitoring efforts with existing USDA Natural Resources Conservation Service's National Resources Inventory private land monitoring program. ARS scientists at the Jornada Experimental Range also created Web-based tools for monitoring data analysis and reporting, mobile and tablet-based data collection applications, and extensive training modules that are deployed with other U.S. agencies and international partners. The inventory, monitoring, and assessment techniques and tools developed at the Jornada Experimental Range are providing managers and policy-makers with information needed to manage resources at local to national scales. (Project No. 6235-11210-007-00D)

**Winter grazing of rangelands reduces wildfire risk and severity of wildfires.**

Though wildfire prevention and response costs U.S. taxpayers more than \$3 billion annually, in 2012, a record was set in eastern Oregon for the amount of rangeland burned by wildfire. Much of the area being burned is prime habitat for sage-grouse, and the fires have created severe hardship for ranchers in the region because of the loss of palatable forage. Research by ARS scientists in Burns, Oregon, demonstrated that winter grazing by livestock altered the abundance and moisture content of fuel for wildfires, and could help reduce the period of wildfire risk from 3 months to less than 1 month. This information will assist private and public land managers in developing strategies to reduce wildfire risk on rangelands, which will benefit livestock production and help preserve essential habitat for sage-grouse and other wildlife. (Project No. 5360-21630-001-00D)

**Patch burning improves production and conservation benefits in semiarid rangelands.**

In the moderately arid regions of the eastern Great Plains, integrating the management of grazing and fire can be an important strategy for adjusting livestock grazing distributions, improving forage quality, and enhancing ecosystem conservation. ARS researchers in Fort Collins, Colorado, and Cheyenne, Wyoming, conducted

October burns on three replicated pastures for 4 years and burned 25 percent of the pasture area each year to determine how forage and livestock production would be affected. Forage production was not affected by burning, but early-season forage quality was enhanced after the burning, and cattle spent more time grazing in recently burned areas during periods of rapid plant growth. The burns also substantially reduced dead biomass and litter. Livestock gains were similar between cattle that grazed in the burned pastures and cattle that grazed in traditionally managed pastures where burning was not conducted. However, habitats for the Mountain Plover, a grassland bird species of concern, was significantly enhanced in pastures where burning had occurred. These findings indicate that combining the management of fire and grazing to improve wildlife habitat can be consistent with, and even complementary to, livestock production goals in semiarid rangelands of the western Great Plains. (Project No. 5409-21610-001-00D)

**Resilience of semiarid rangelands to summer fire and post-fire grazing utilization.**

Resource managers need information about the seasonal effects of fire during summer—when most wildfires occur—because understanding how plants respond to grazing after a summer fire can help reduce the ecological and economic risks associated with wildfire. ARS researchers in Miles City, Montana, determined that summer fires had no first-year effect on any plant productivity and that grazing after fire had no effect on total above-ground productivity. Their findings indicated that fire and grazing increased grass productivity 16 percent, and reduced forbs by 51 percent, annual grasses by 49 percent, and litter by 46 percent. They also determined that during the first growing season after summer fire, livestock could consume up to 50 percent of the available forage without harming the productivity of semiarid rangeland plant communities. Restricting livestock grazing the year after summer fire did not increase plant productivity or shift species composition. These observations were all consistent among dry, wet, and nearaverage years, indicating that plant responses are species-specific and not significantly affected by precipitation patterns. Resource managers are using these results in post-fire grazing management decisions, particularly for federally managed lands that required 1 to 3 years of livestock removal following fire, which benefits livestock producers and facilitates cost-effective grazing on Federal lands. (Project No. 5434-21630-00300D)

**Rapid method for characterizing tannins improves nitrogen use efficiency on dairy farms.**

Condensed tannins, a component in many plants, have been shown to improve nitrogen use efficiency at different steps in milk production, including silage production, rumen efficiency, and manure chemistry. Condensed tannins are often difficult to characterize because of their complex chemical structure, and current chemical analysis methods are cumbersome and time-consuming. ARS scientists in Madison, Wisconsin, have developed a rapid characterization method for condensed tannins based on nuclear magnetic resonance spectroscopic analysis. This method can determine the chemical components that make up individual tannins, the ratios of different tannin components, and the size of the individual purified tannins. This information is critical to accurately characterize tannins used in protein precipitation, protein degradation, and enzyme inhibition studies. The method can be used not only in dairy related research and production, but in any discipline or industry where tannins have an important function. A more comprehensive understanding of how condensed tannins work will enable farmers to develop farm/feed management processes and support cost-effective and environmentally beneficial animal production strategies. (Project No. 3655-21000-055-00D)

**Improved breeding strategies to aid organic small ruminant production.**

In the United States, the greatest barriers to the organic production of small ruminant livestock, such as sheep and goats, are gastrointestinal parasite infections that can result in reduced weight gains and death. ARS scientists in Booneville, Arkansas, are leading research in a multi-institutional, multi-disciplinary team funded by NIFA's Organic Agriculture Research and Extension Initiative and the Small Business Innovation Research program, and have developed selection tools to aid in the control of gastrointestinal nematodes for organic production of small ruminants. Other project collaborators include researchers from Louisiana State University, Virginia Tech, Fort Valley State University, and the University of Arkansas and farmers. This research demonstrated that breeding for parasite resistance in sheep can eliminate the need for most deworming and reduce mortality and morbidity, especially when coupled with good livestock nutrition and pasture management. The research has resulted in farmer-friendly publications available through the National Center for Appropriate Technology and the Web site

of the American Consortium for Small Ruminant Parasite Control that will benefit organic producers interested in ruminant production. (Project No. 6227-21310-009-00D)

**A mineral seed treatment suitable for organic alfalfa production systems.**

The most common fungicide used on alfalfa seed does not protect against all soilborne diseases and cannot be used in organic production systems. ARS researchers in St. Paul, Minnesota, determined that a novel mineral seed treatment using aluminosilicate (natural zeolite)—which is allowed under the National Organic Plan (NOP) Rule 205.203(d)(2)—gave significantly greater control of major alfalfa seedling diseases than the existing Apron XL seed treatment. The mineral treatment significantly controlled multiple strains of the pathogen responsible for Aphanomyces root rot (for which Apron XL is ineffective), and in the field protected a greater percentage of plants than the Apron XL treatment. An added benefit is that aluminosilicate did not harm the soil bacteria needed by alfalfa to fix nitrogen. This research indicates that the aluminosilicate mineral seed treatment is a promising new means of controlling seedling diseases in conventional and organic alfalfa production systems. (Project No. 3640-12210-002-00D)

**Recycling nutrients from dairy storage lagoons may provide new source of supplemental fertilizers.**

Dairy producers often use lagoons to store livestock manure, but the manure nutrients can leach out and contaminate the surrounding soil. ARS scientists in Prosser, Washington, conducted laboratory, greenhouse, and field studies and determined that these nutrients could be recovered from animal manure anaerobic digestion systems and supply additional nitrogen, phosphorus and potassium for potato, sweet corn, wheat and bean production. Using anaerobic digestion systems to recover nutrients from manure would provide another source of fertilizer and offset fertilizer costs in specialty crop production. (Project No: 5354-21660-003-00D)

**Monitoring environmental stress in wheat to improve precision agriculture.**

One goal of precision agriculture is to manage within-field variability of yield quantity and quality. It has been possible for years to map the variability of yield quantity, but tools to map yield quality are still needed. ARS researchers in Pendleton, Oregon, have developed a real-time, on-combine system that can be used in the field to measure yield quality at the grain protein level. Producers can use this system to identify specific regions within fields where environmental stress is affecting grain yield quality, which will help improve precision agricultural management strategies that increase yield quantity and quality. (Project No. 5356-21610-002-00D)

**Land use practices and stream and river water quality.** Assessing how land use alters water quality of nearby streams and rivers is an important aspect of pollution monitoring and natural resource stewardship. Tools are needed that can quantify how land use alters stream and river water quality over long time periods. ARS scientists in Corvallis, Oregon, collected data over an 8-year period to define 56 land use patterns of crops, forests, and urban development that represented 99 percent of the Willamette River Basin of western Oregon. The data collected were incorporated into the Soil and Water Assessment Tool model. In validation tests, the model showed an increased capability to predict how land management altered nutrient and sediment load in streams and rivers. Researchers will now be able to determine the environmental consequences of changing land use patterns. (Project No. 5358-21410-003-00D)

**New farm-scale gasifier unit can increase sustainability by creating value-added products.**

Finding new uses for agricultural byproducts can help increase the economic resilience of individual farms. ARS scientists in Corvallis, Oregon, worked with a private non-profit group to develop and test a farm-scale gasification unit that can convert residues from seed cleaning into value-added products. This public-private collaboration demonstrated that the unit could convert over 400 pounds of feedstock per hour into syngas and organic carbon-rich biochar that could improve the organic content of acidic soils in eastern Washington State. This work led to the formation of a company that will make the technology available to farmers and other owners of seed cleaning mills. (Project No. 5358-21410-003-00D)

**Increasing the efficiency of nitrogen applications in deficit irrigation.**

When water is limited, nitrogen requirements to maximize crop production changes which makes it economically important to know the appropriate amount of nitrogen to apply. ARS researchers in Fort Collins, Colorado, updated the ARS Root Zone Water Quality Model 2 (RZWQM2) to determine the optimal amounts of nitrogen to be applied to match seven different levels of available soil moisture. Validation of this model with field data indicated that RZWQM2 could be used to optimize nitrogen application rates to different levels of available soil moisture for corn producers in Colorado. (Project No. 5402-61660-007-00D)

**Increasing rotational diversity can benefit sugarbeet.**

Sugarbeet is susceptible to numerous diseases, insects, and weed infestations. ARS scientists in Sidney, Montana, and sugar industry researchers demonstrated that switching from a 2- to a 3-year rotation can reduce the risk of pest infestations and can help spread economic risk. In addition, adding an annual legume as a rotational crop can increase soil levels of organically fixed nitrogen and reduce fertilizer application costs. This practice can lead to reduced pest pressures and higher profits for sugarbeet growers in Montana. (Project No. 5436-13210-006-00D)

**Bacteria may help prevent sugarbeet disease.**

Leaf spot disease is a fungus that affects sugarbeet production in Montana. ARS researchers in Sidney, Montana, tested various bacteria found in dryland fields and discovered that one bacterium, *Pantoea agglomerans*, can attack the leaf spot disease fungus by degrading its cell walls. In greenhouse trials, adding this bacterium to sugarbeet infected with leaf spot fungal spores reduced the incidence of leaf spot disease, which suggests that the bacterium could become an ecological replacement to fungicides typically used to fight this disease. (Project No. 5436-13210-006-00D)

**Management practices to improve production in dryland malt barley.**

Soil degradation reduces production levels and can limit available soil nutrients. Conventional tillage with malt barley fallow rotation has reduced soil quality and annual grain yield by contributing to the loss of soil organic matter. ARS scientists in Sidney, Montana, have identified a robust management practice that includes a no-till barley pea rotation that can minimize soil degradation. Implementation of this practice can reduce the need for nitrogen fertilization by 54 percent, and nitrogen losses through leaching, volatilization, and denitrification by 125 percent. At the same time, this practice was found to increase soil carbon storage by 11 percent and enhance malt barley yield and quality as much as 44 percent compared with traditional tillage practices. Implementation of this practice by producers can reduce chemical input and energy needs, enhance soil quality, and sustain dryland malt barley yield and quality. (Project No. 5436-13210-006-00D)

**Minimal tillage can increase soil carbon sequestration in the southeastern United States.**

The ability of soil to sequester carbon can improve long-term soil health while acting to mitigate greenhouse gas emissions. Conservation systems that utilize minimal soil disturbance combined with high-residue cover crops enhance carbon sequestration, but no tool is available to determine carbon sequestration amounts across specific conservation systems. ARS scientists in Auburn, Alabama, compared numerous conservation tillage systems and winter cover crops to derive a means to quantify and compare how much carbon each system sequestered. They determined that cover crops added an average of 2,500 kilograms of carbon per hectare, while corn residue only added 1,340 kilograms of carbon per hectare to the soil each year. The scientists concluded that a number of winter cover crops have significant potential to sequester additional carbon. The findings demonstrate that the use of conservation systems that include cover crops can improve soil health and could offset CO<sub>2</sub> emissions across degraded coast plain soils for the southeastern United States. (Project No. 6420-12610-005-00D)

**Novel microbial oil has antibacterial activity.**

Antimicrobial resistance, a major health concern, has decreased the effectiveness of therapeutic drugs to treat and prevent infectious disease. As a result, antibiotic alternatives are needed to maintain the health and welfare of animals. ARS scientists in Peoria, Illinois, collaborated with a scientist from Rangsit University in Thailand to test a novel oil produced by the fungus *Aureobasidium pullulans* for antibacterial activity. The oil, known as one of the liamocins, was produced through bioconversion of a variety of sugars and lignocellulosic feedstocks and

was found to preferentially inhibit the growth of strains of the pathogenic bacteria *Streptococcus*. The antibacterial oil can improve animal health in the dairy, swine, and aquaculture industries, and can support the biorefining industry by providing a new a high-value bioproduct. (Project No. 2008 3620-41000-135-00D)

**Changing landfills into biorefineries.**

To provide sufficient quantities of biomass sources between growing seasons, ARS researchers in Albany, California, developed a large pilot scale biorefinery located at the Salinas, California, Crazy Horse Landfill that converts rural and urban solid waste into ethanol, biogas, compost, and value-added recyclables. Each ton of food processing waste at the landfill currently can be converted into 65 gallons of ethanol. If the same biomass source is converted to liquefied natural biogas, which has the same burn rate as 100 percent ethanol, it yields 108 gallons of transportation fuel, which can be used to power diesel turbines. Together, ARS and the city of Salinas are creating an “energy park” that converts both agricultural biomass and curb collected garbage into bioenergy in the same biorefinery, which demonstrates the facility’s remarkable flexibility in handling and processing different feedstock supplies. (Project No. 5325-41000-049-00D)

**Sustainable biodiesel additives improves cold weather flow.**

The cold flow properties of fatty acid methyl esters (biodiesel) are relatively poor and detract from commercial viability of biodiesel as a fuel source during cold weather. Synthetic cold flow improver (CFI) additives made from soybean, canola, and palm oils have been shown to increase the ability of biodiesel to flow at low temperatures. ARS scientists in Peoria, Illinois, and Wyndmoor, Pennsylvania, collaborated on the synthesis and testing of CFI additives obtained from non-food resources such as waste cooking oil. Results from the research benefits farmers who supply seed oils for biodiesel conversion by making the fuel more flowable and marketable during cooler seasons. Biodiesel fuel producers, distributors, and consumers will also benefit from better flowability and performance in cold weather. (Project No. 5010-41000-148-00D)

**Novel yeast strains reduce the price of biomass conversion to ethanol.**

Traditional yeasts convert sugars in cereal grains to ethanol, but these yeasts cannot use the sugar xylose, which is the second most abundant sugar in corn stover, switchgrass, and lignocellulose feedstocks. In addition, the process of converting sugars to ethanol results in toxic conditions that inhibit all yeast fermenting activities. *Saccharomyces stipitis* is a native pentose-sugar fermenting yeast that ARS scientists in Peoria, Illinois, cultured in an ethanol-challenged continuous culture system to force the development of robust yeast isolates. These isolates were able to overcome toxic conditions and produced ethanol using either highly acid- or base-pretreated corn stover or switchgrass. The novel yeast isolates reduced growth lag time, significantly enhanced fermentation rates, improved ethanol tolerance and yield, and rapidly and economically generated recoverable ethanol at acidic pH levels (which potentially inhibit ethanol fermentation). Compared with parent yeasts, these new yeast isolates reduce ethanol selling costs by \$0.31/gallon, an accomplishment that advances national efforts to develop renewable fuel systems to stimulate the rural economy, preserve the environment, and reduce dependence on foreign oil. (Project No. 362041000-147-00D)

**Cost-effective process technology for butanol production from corn stover.**

Butanol is an advanced biofuel that packs 30 percent more energy than ethanol on a per gallon basis. It is produced via fermentation of sugars; however, butanol should be removed as it is produced during fermentation because above a certain concentration, butanol inhibits its own production. Thus the key to producing butanol economically from corn stover is a threestep process: 1) convert pretreated corn stover to sugars using enzymes; 2) ferment the sugars to butanol; and 3) recover butanol as it is generated. ARS scientists in Peoria, Illinois, developed this novel three-step process by pretreating the corn stover with a dilute acid coupled with vacuum distillation to allow for continuous butanol recovery. The production cost for butanol from corn stover by this process was estimated to be at \$3.42/gallon, whereas from corn it was \$4.39/gallon. This newly developed fermentation/recovery process offers a new, costeffective method of producing butanol. (Project No. 3620-41000-149-00D)

**Identifying ethanol-tolerant proteins in bacteria that convert feedstocks to ethanol.**

Lactic acid bacteria are used in the industrial fermentation of agricultural biomass to biofuels such as ethanol, but these bacteria are sensitive to the elevated concentrations of ethanol generated during the conversion process. ARS scientists in Peoria, Illinois, examined a strain of lactic acid bacteria to identify proteins that confer ethanol tolerance to the bacterium. Twenty proteins that varied in response to elevated ethanol concentrations were identified. These results provide information on the production and regulation of the proteins involved in ethanol tolerance and will be useful in efforts to genetically improve microbial strains that can more efficiently and completely convert agricultural biomass to biofuels and bioproducts. (Project No. 3620-41000-135-00D)



## CROP PRODUCTION AND PROTECTION

### National Programs:

- **Plant Diseases, NP 303**
- **Crop Production, NP 305**
- **Plant Genetic Resources, Genomics and Genetic Improvement, NP 301**
- **Crop Protection and Quarantine, NP 304**

### **Conventionally bred sweet orange-like hybrid and new rootstocks with tolerance to citrus greening entered large-scale grower trails.**

Citrus greening or huanglongbing (HLB) is the most serious threat to citrus production worldwide and has reduced Florida citrus production by 50 percent. No inherent genetic protection for citrus trees has been available for U.S. citrus growers. However, in 2014, ARS researchers in Fort Pierce, Florida, released a new hybrid sweet orange with high quality fruit that displays excellent tolerance to HLB disease. These trees have been propagated at a commercial nursery and were placed in 2015 in replicated plantings on six grower sites with other advanced sweet orange-like selections. Nine new citrus rootstocks have also been developed that display much higher sweet orange fruit productivity and tree health in field trials in areas that have been severely affected by HLB. These rootstocks have been entered into the Florida clean budwood program and are being propagated for entry into large-scale grower trials. Release of the tolerant hybrid and rootstocks offers a new option for citrus growers for production management in the presence of citrus greening. (Project No. 6618-21000-014-00D)

### **Genetic inheritance of cooking time in beans.**

Dry beans are a nutrient-dense, low-cost food and an excellent cost effective food choice for consumers. In spite of this value, bean consumption is limited—especially in developing countries—because of their long cooking times and the high amount of fuel needed for cooking. To develop bean varieties that cook more quickly, plant breeders need information about how genetic traits affect cooking time and how metabolic activity affects those traits. ARS scientists in East Lansing, Michigan, evaluated a group of 240 Andean bean lines for genetic differences in cooking time. The average cooking time was 38 minutes, ranging from 19 to 87 minutes. Genetic elements associated with cooking time were detected on chromosomes 2 and 10, with evidence suggesting that enzymes coded on chromosome 2 (pectin methyltransferases) may influence cooking time. In each of the four market classes evaluated (yellow, cranberry, light red kidney, and red mottled), the genotypes that required the shortest cooking time also retained a higher percentage of protein and iron, indicating that these bean varieties might potentially provide the most benefit to consumers in terms of convenience and added nutrition. (Project No. 3635-21430-010-00D)

**Soybean genes that retard cyst nematode development.**

Soybean cyst nematodes attack the roots of soybean plants and cause approximately \$1-2 billion in damage each year to the U.S. soybean industry. Genetic resistance combined with crop rotations is the most sustainable way to manage this pest, but the pathogen changes so rapidly that this is a challenging strategy. Toward providing a longer-term source of genetic resistance, ARS researchers in Beltsville, Maryland, designed and evaluated multiple DNA constructs to provide resistance to both soybean cyst and root-knot nematodes. The DNA segments successfully decreased galls formed by root-knot nematode and cysts formed by the soybean cyst nematode by approximately 70-90 percent. This new strategy using several gene constructs can now be exploited by soybean breeders to combat nematodes that lower soybean yields, and could be adopted for use with other crop species. The technology has been patented and transferred to industry partners, and products are being developed for commercialization. (Project No. 1245-21220-23200D)

**Genes for better frost tolerance.**

It is known that variation in the ability of winter wheat to survive the winter months in the field is associated with differences in the vernalization 1 (VRN1) and frost resistance 2 (FR2) genes, but knowledge of how specific forms of the genes influence winter hardiness and possible interactions among them is lacking. ARS researchers in Pullman, Washington, assayed variation in the composition of the genes and the number of copies at the FR2 and VRN1 loci in a large set of winter and spring wheat genotypes from around the world representing a broad range of freezing tolerance. Results indicate that selection of wheat varieties with a specific form of the FR2 gene (the FR-A2-T allele) and three copies of the recessive vrn-A1 allele would be a good strategy for improving frost tolerance in winter wheat. These findings provide wheat breeders with valuable new molecular tools for improving winter survival in wheat. (Project No. 5348-21000-03000D)

**Saving energy and reducing ginning costs by improving ginning efficiency.**

Cotton cultivars differ in how strongly fibers are attached to the seed, and cultivars with less fiber-seed attachment force can be ginned faster with less energy and fiber damage. ARS cotton breeders and engineers in Stoneville, Mississippi, determined that percent fuzz was correlated with ginning efficiency and that selecting for genotypes with low fuzz percentage resulted in genotypes with better ginning efficiency. This finding will help cotton breeders develop cotton cultivars that gin faster with lower ginning energy requirements and high fiber quality. (Project No. 6402-21000-051-00D)

**Successful preservation of oaks under genebank conditions.**

Oaks, key tree species for many temperate and aridland forests, furnish highly valuable wood for construction, furniture, and other uses. Endangered oak species require protection in genebanks, but until now, that has been problematic because acorns did not survive under conventional ultra-cold genebank storage conditions. ARS researchers in Fort Collins, Colorado, and their collaborators developed methods for successfully preserving under ultra-cold conditions embryos dissected from acorns of more than 20 oak species. This breakthrough will enable ARS and other genebanks to effectively protect the gene pool of endangered, highly valuable oak species. (Project No. 5402-21000014-00D)

**Next-generation sequencing of organellar genomes in cranberry to enhance breeding efficiency.**

ARS scientists in Madison, Wisconsin, used molecular methods and computer-based approaches to reconstruct the cranberry plastid and mitochondrial genetic codes. These cellular organelles are involved in energy formation (photosynthesis) and utilization (respiration). This organelle sequence enables the study of photosynthesis and respiration in cranberry; key processes in the formation of fruit and ultimately cranberry yield. The genetic codes of cranberry organelles deciphered through this research are the first and only codes available in the entire cranberry family, which comprise thousands of species without previous information. Ultimately, the genetic information about energy production/utilization systems in cranberry can be used by plant breeders to breed more energy-efficient cranberries and sister species such as blueberry and lingonberry. (Project No. 3655-21220-00300D)

**Identifying cacao varieties from a sample of only one bean.**

Cacao, the source of cocoa, is grown primarily on small farms primarily in West Africa. Production and marketing of specialty, high-value cocoa can provide economic opportunities for growers in the developing world and greater profits for the cocoa/chocolate industry. But to realize those benefits, the varietal identity for high-value cacao, some of which is rather rare, must be authenticated. ARS researchers in Beltsville, Maryland, developed a new method of DNA testing that can identify a cacao variety from a single bean. This new testing method can more efficiently identify high-value cacao for on-farm protection and propagation, and also can authenticate commercial sources for this increasingly high-value product. (Project No. 1245-21000-267-00D)

**Physiological traits and metabolites of cacao seedlings influenced by potassium in sand-culture.**

An inadequate supply of soil potassium where cacao is grown greatly affects cacao yield potentials. ARS scientists in Beltsville, Maryland, evaluated the effects of diverse levels of potassium on growth and physiology traits and metabolites of cacao genotypes. The study revealed that potassium played a critical role in growth and development, and significantly improved physiological traits (chlorophyll b and a/b ratio) and the levels fructose, glucose, myoinositol, raffinose, and starch in cacao leaves. The sand-culture method adapted is useful in identification of potassium-efficient cacao genotypes for cacao improvement programs that have a limiting soil potassium supply. Knowledge of potassium use in cacao will help cacao farmers develop suitable crop and fertilization management practices to improve cacao sustainability and yield. (Project No. 124521000-278-00D)

**Producing “clean” berry crops free of targeted pathogens.**

To be competitive and profitable, berry producers require clean plants (i.e., those with no viruses) that establish quickly and have higher yields and fruit quality than diseased plants. ARS scientists in Corvallis, Oregon, with collaborators at the University of Idaho evaluated strawberry, blackberry, raspberry, elderberry, grape, and blueberry and eliminated viruses from multiple cultivars and advanced selections as part of the National Clean Plant Network with funding from USDA-APHIS. These resulting “clean” plants are the starting material for certification programs that monitor and regulate the large-scale production of these crops. The testing and cleanup that occurred through this effort is also facilitating the export of more than 50 million berry plants for planting in other countries. (Project No. 5358-21220-002-00D)

**A rotating cross-arm trellis system for blackberry production.**

Blackberry production in the U.S. Midwest is limited by low winter temperatures that kill the fruit buds and vines. ARS researchers in Kearneysville, West Virginia, developed a rotating, cross-arm trellis system that allows the vines to be rotated to the ground and covered with a protective, floating row cover as needed to protect dormant vines from extreme temperatures. This new production system reduces the risks of crop failure and major crop losses from extreme and untimely cold temperatures. In January-February 2014, much of the Midwest experienced temperatures colder than  $-20^{\circ}\text{C}$ , which killed blackberry plants grown in conventional systems with no winter protection, leaving less than 10 percent of a normal crop to be harvested. In contrast, growers who used the rotating, cross-arm trellis and winter protection system saw little winter damage and harvested 80 percent of a normal crop in 2014. Since 2010, 120 hectares of new blackberry plantings on 40 farms (1 to 10 hectares in size) from Pennsylvania to Iowa have been established using the rotating, cross-arm trellis system. In 2014 alone, these new plantings are expected to generate \$60,000 per hectare. (Project No. 1931-21000-018-00D)

**Profitable practices for organic production of highbush blueberries identified.**

ARS scientists in Corvallis, Oregon, conducted a long-term field study in collaboration with Oregon State University to evaluate management practices for organic production of highbush blueberry. The cultivars included ‘Duke’ (early-season) and ‘Liberty’ (mid- to late-season), and the practices included flat or raised planting beds, two fertilizers (feather meal and fish emulsion fertilizer applied at low and high rates), and three different types of mulch (sawdust, yard debris compost covered with sawdust, and weed mat). The greatest growth and yield were found when plants were grown on raised beds, fertilized with a low rate of fish emulsion or a high rate of feather meal, and mulched with either compost plus sawdust or weed mat. The use of raised beds and weed mat is becoming popular for organic blueberry production in the Pacific Northwest, in part as a result of

this study. Both practices increase growth and early production of the crop and the later improves weed control and increases economic returns. (Project No. 535821000-042-00D)

#### **What's really in your black raspberry supplements?**

Controls are needed to ensure that dietary supplements already in the marketplace meet a certain minimum quality and that they contain their labeled contents (i.e., black raspberry supplements contain a minimum anthocyanin concentration). All available black raspberry products marketed as supplements were purchased for this work. Each was analyzed for authenticity and anthocyanin concentration by ARS researchers in Parma, Idaho. Seven out of 19 samples did not contain any black raspberry fruit, and 3 out of those 7 had no detectable anthocyanin. This shows that food sources remain a more reliable method of obtaining dietary phenolics than dietary supplements. (Project No. 5358-21000-047-00D)

#### **Intelligent spraying system for nursery and orchard applications.**

The use of conventional spray applications to achieve effective pest control in floral, nursery, and fruit crop production requires excessive amounts of pesticides. ARS researchers in Wooster, Ohio, invented an automated, variable rate, air-assisted precision sprayer that minimizes human involvement in determining the amount of spray needed for application. This intelligent spraying system characterizes the presence, size, shape, and foliage density of target trees and applies the optimum amount of pesticide. Field experiments have shown that the intelligent sprayer reduces the variation in spray deposition due to changes in tree structure and species, and increases the uniformity of spray deposition on targets at different growth stages. The pest control efficacies of the new sprayer provide an environmentally responsible approach. The new sprayer also reduces average pesticide use by up to 68 percent, with an annual average cost savings of \$230 per acre. (Project No. 3607-21620-008-00D)

#### **Adapted varieties save wheat production in acid soils with aluminum toxicity.**

ARS scientists in Pullman, Washington, have determined that low soil pH and aluminum toxicity may be responsible for yield losses of up to 90 percent in over 50,000 acres of wheat in Washington, and Idaho. Producers can attempt to mitigate these conditions by growing triticale or heavily liming the soil, but neither option is cost-effective. In collaboration with scientists at Washington State University, ARS researchers evaluated wheat varieties adapted to these soil conditions, and identified several aluminum-tolerant varieties that gave significantly improved yields. These findings provide wheat growers in this region with cost-effective alternatives for improving their production. (Project No. 5348-22000-016-00D)

#### **Sugar and cane yields optimized with variable-rate application of fertilizer.**

Sugarcane crops must receive proper levels of nitrogen and potassium for profitable yields. ARS scientists in Houma, Louisiana, conducted studies to determine whether variable-rate application of nitrogen and potassium could help optimize sugarcane yields while also increasing production efficiency. Results from 2 years of field trials suggest that variable-rate application of both may offer Louisiana sugarcane producers a viable method for decreasing costs while increasing production efficiency. In the study, nitrogen rates were decreased by up to 25 percent. Data from these studies were used to reformulate Louisiana State University AgCenter fertilizer recommendations. Many growers have adopted these recommendations and have already realized greater cane and sugar yields. (Project No. 6410-12210-002-00D)

#### **Increasing access to new genetic resources to protect sugarcane.**

Sugarcane producers and industry need access to new genetic crop diversity to thwart numerous endemic and invasive pests, diversify onto marginal land, and adapt to climatic change. However, sugarcane germplasm imports to the United States have been restricted to "seed cane," or cane pieces, which has limited U.S. access to genetic diversity. ARS scientists in Houma, Louisiana, and at Canal Point, Florida, working with university and international sugarcane researchers, determined the risk of importing pathogens on true seed (termed "fuzz"), which was previously unknown. All test results were negative, and no seedling from parents infected with known pathogens was found to be infected. These results contributed to a decision made by APHIS that fuzz can now be imported into the United States under approved protocols. The result is that major new genetic diversity can now

be provided to all sugarcane breeding projects in the United States which will help can producers manage disease, respond to climate challenges, and protect profits. (Project No. 6410-22000-016-00D)

**Grapevine yield estimation automated.**

Worldwide, grapes are the most planted fruit crop and rank third in tonnage produced. It is important to estimate yield in vineyards to allow for contract negotiation, harvest logistics, and marketing projections. ARS scientists in Prosser, Washington, developed a trellis tension monitoring system that is as good as or better than the current labor-intensive method used to estimate crop yields. This system monitors the tension in the trellis wire as the fruit increases in size. Fruit yields can be estimated before veraison (the onset of ripening) to within 20 percent of actual yields. This information is being used to optimize processing capacity and predict labor needs. (Project No. 5358-21000-047-00D)

**Cover crops and no-till systems benefit soils without negatively affecting wine-grape production in an irrigated vineyard.**

ARS researchers in Davis, California, evaluated the effects of cover crops and no-till practices on winegrape production in Lodi, California, in the Central Valley, where diminished air quality from particulates could mandate the use of no-till soil management practices. Over 3 years, soil nutrient availability, vine nutrition, growth, and yield characteristics of *Vitis vinifera* cv. merlot, grown under regulated deficit irrigation, were not affected by cover crops and no-till systems. Importantly, wine-grape yields from the zones of the vineyard where cover crops and no-till practices had occurred were similar to those of conventional management consisting of weed cover in winter followed by repeated tillage between April and September. The outcomes indicate that growers can use cover crops and/or no-till practices to reduce erosion and air particulates, and improve soil infiltration with no effect on yield and nutrition in irrigated, mature vineyards. (Project No. 5306-21220-005-00D)

**Early detection of grapevine trunk diseases.**

Detection of wood-canker pathogens of grapevines (aka trunk diseases) is limited to the late stage of infection, when disease symptoms have become obvious and the opportunity for disease prevention is lost. Non-destructive detection would benefit from identification of grape genes expressed in symptomless leaves at the early stage of infection. In an effort to develop an early detection tool, ARS researchers in Davis, California, demonstrated proof of concept that the early stage of infection is detectable by sampling symptomless grape leaves for grape genes that are expressed before the fungus spreads through the stem. A detection tool for this early stage of infection will allow quick removal of infected plants and control of the disease in both nurseries and commercial vineyards. This is critical for growers who would otherwise bear the cost of unknowingly farming diseased grapevines doomed to a lifetime of low productivity. (Project No. 5306-21220-006-00D)

**Crop adaptation to extreme environments.**

Acidic soils constitute 40 percent of arable land in the tropics and subtropics. Aluminum (Al) toxicity in acidic soil stunts and damages root growth resulting in significant reductions in crop yields due to nutritional deficiencies and drought stress. Rice is the most Al-tolerant of the major cereal crops. ARS and university scientists in Ithaca, New York, showed that rice tolerance to Al is due in part to a novel transporter gene (OsNRAT1) that promotes Al sequestration into the root cell vacuole. OsNRAT1 is sufficient for promoting Al transport in diverse systems from plants to yeast. This knowledge may allow the growing of target crops with Al tolerance in acidic soils using conventional breeding or transgenic approaches. (Project No. 1907-21000-036-00D)

**Effect of climate change on crop nutritional quality.**

Producers and nutritionists are concerned about how climate change might affect the nutritional qualities of food crops. ARS researchers in Aberdeen, Idaho, and Urbana, Illinois, and multinational collaborators determined how climate change could affect the nutritional qualities of several staple crops, including wheat, rice, maize, sorghum, and soybean. They grew these crops to maturity under varying levels of atmospheric carbon dioxide, which are expected to become elevated because of climate change. In the first assessment of its kind, seed nutrient content of zinc, iron, and protein nutrition was evaluated. Scientists also measured seed phytic acid content, which is

critically important for determining iron and zinc bioavailability. Study results indicated that although seed phytic acid was not largely altered by elevated carbon dioxide levels, seed zinc, iron, and protein levels declined. Iron and zinc deficiencies are significant global public health challenges that impair the health of an estimated two billion people worldwide. These findings, which were published in the journal *Nature*, provide important new information for understanding how climate change could affect the nutritional quality of crops. (Project No. 5366-21000-030-00D)

**Gasified rice hull biochar is a source of phosphorus and potassium for container-grown plants.**

Worldwide phosphorus supplies are becoming limited and, as a result, phosphorus fertilizer prices are rapidly increasing. Phosphorus is also implicated in surface water impairment when it is leached from crop production sites into surface water systems. ARS researchers in Wooster, Ohio, documented that gasified rice hull biochar (GRHB), a waste byproduct of rice processing, could be used as a source of phosphorus in production of ornamental crops in containers. GRHB was incorporated into typical greenhouse container substrates at 5 percent or 10 percent by volume. Plants received no other source of phosphorus, yet grew vigorously. ARS research documented the changes in substrate chemical and physical properties as a result of GRHB amendment, as well as plant response. Greenhouse and nursery producers can use this research to grow crops by using a recycled form of phosphorus, without reliance on traditional phosphorus fertilizer supplies. (Project No. 3607-21000-01400D)

**An airborne two-camera imaging system for agricultural remote sensing.**

Recent advances in imaging technologies have made consumer-grade digital cameras an attractive option for remote sensing due to their low cost, compact size, and user-friendliness. ARS researchers in College Station, Texas, assembled and evaluated an airborne multispectral imaging system on the basis of two identical consumer-grade Canon cameras. One camera captures normal color images, whereas the other obtains near-infrared images with filtering techniques. The color camera is also equipped with a GPS receiver to allow images to be geo-tagged. A remote control is used to trigger both cameras simultaneously. Geo-tagged images from the system can be viewed on any image viewer and on Google Earth for quick assessment before digital image analysis. The imaging system was tested under various flight and land cover conditions; optimal camera settings were determined for airborne image acquisition. Analysis of example images established that this system has good potential for crop condition assessment, pest detection, precision aerial application, and other agricultural applications. (Project No. 6202-22000-03200D)

**Better integrated management of pecan foliar and fruit diseases, with emphasis on pecan scab.**

Fungicide resistance is a looming issue for pecan growers. Recent work by ARS scientists in Byron, Georgia, identified a novel biorational compound with activity against pecan scab. The compound, trans-cinnamic acid, is produced by symbiotic bacteria from the gut of entomopathogenic nematodes. Isolation of the compound and in vitro testing showed it to be 100 percent efficacious in reducing scab. (Project No. 6606-21220-012-00D)

**New discovery of the genetic factors that confer Ug99 wheat stem rust resistance.**

Ug99 wheat stem rust has not yet been found in the United States, but it is spreading overseas and is considered a potential threat to up to 90 percent of the world's wheat. Durable resistance to wheat stem rust in adult wheat plants is highly desired to protect wheat production from major stem rust losses. ARS scientists in St. Paul, Minnesota, identified and determined that a combination of genetic factors can confer adult resistance to wheat stem rust in wheat varieties adapted for the United States. These results can be used by wheat breeders to develop new wheat varieties with even more effective genetic resistance to Ug99 and other wheat stem rusts. (Project No. 3640-21220-02100D)

**National Sclerotinia Initiative develops effective screening tools for sunflower.**

The sclerotinia diseases are some of the most important diseases of sunflower in the Northern Great Plains. ARS scientists in Fargo, North Dakota, together with Sclerotinia Initiative-funded collaborators, have developed a standardized regional approach to identify significant differences in the susceptibility of sunflower hybrids to sclerotinia. Building on that successful result, the researchers have developed field-scale inoculation procedures and misting systems that have enabled U.S. sunflower breeders to identify sunflower hybrids with resistance to

sclerotinia. The system has been effectively implemented to assess sclerotinia resistance of newly released commercial hybrids at five regional “common garden” nurseries, providing growers with site-specific and overall performance characteristics of individual sunflower hybrids, and facilitating the release of new oilseed sunflower genetic lines with improved head rot resistance. The standardized assessments have significantly increased the number of hybrids identified with improved levels of sclerotinia resistance for U.S. sunflower growers whose 2012 crop production was valued at \$727.8 million. (Project No. 5442-21220-028-00D)

**Remediating boll weevil pheromone trap detection failures.**

Boll weevil eradication programs rely on pheromone traps to detect incipient weevil populations and to flag the need for insecticide treatments. Nevertheless, substantial weevil infestations have been detected in cotton fields even though surrounding pheromone traps failed to detect the weevils. ARS researchers in College Station, Texas, in collaboration with the Texas Boll Weevil Eradication Foundation (TBWEF) and the National Cotton Council, investigated the quality of pheromone lures used by TBWEF and determined that some weevil populations produce a unique blend of pheromone and no longer responded to the commercial pheromone formulation. As a result of this research, TBWEF adopted a stringent quality testing program and a shorter replacement interval for lures in potentially infested areas. After implementing the change, boll weevils were eradicated from the targeted zone within 3 years, which eliminated the need for insecticide applications and reduced annual grower assessments by \$9 million. (Project No. 6202-22000-029-00D)

**The citrus pathogen *Xylella fastidiosa* cannot be transmitted to seedlings through infected seed.**

Citrus variegated chlorosis, which is caused by *Xylella fastidiosa*, is an important bacterial disease of citrus in South America and a potential threat to citrus producers in the United States. ARS researchers in Beltsville, Maryland, collaborated with citrus researchers and Fundecitrus of Sao Paulo, Brazil, to determine if chlorosis can be transmitted by seed. Researchers at Fundecitrus extracted seeds from healthy and diseased sweet orange fruit and sent the seeds to Beltsville, where ARS researchers determined that the *Xylella fastidiosa* pathogen is not transmitted to seedlings through infected seed. The results provide new information on how citrus diseases are transmitted and help the citrus fruit producers involved in international trade manage threats posed by plant disease. (Project No. 1245-22000-281-00D)

**Controlling the Asian citrus psyllid, the insect vector of citrus greening disease.**

Citrus greening is now found in all citrus growing regions of Florida, and is responsible for a decrease in marketable fruit by more than 50 percent. ARS scientists in Fort Pierce, Florida, are targeting their research to disrupt transmission of the disease by the Asian citrus psyllid, a small insect that sucks the plant’s juices. In 2014, they identified natural products with potential to block the ability of the psyllid to feed. A promising strategy is the application of non-transgeneic RNAi to inhibit transmission of the disease and the viability of the psyllid. The scientists developed delivery systems for the RNAi for root drench, foliar spray, and trunk injection. Results show evidence of psyllid mortality within 2 to 4 weeks after root drench and trunk injection. These results can be integrated into multi-pronged methods for the industry to combat the psyllid to avoid transmission of the citrus greening disease. (Project No. 6618-22320-001-00D)

**Establishing the host status of litchi and rambutan for the West Indian fruit fly.**

The host status of litchi and rambutan for the West Indian fruit fly was unknown. An extensive survey of mature fruit collected from the field (3,732 litchi and 5,534 rambutan fruits) by ARS researchers in Mayaguez, Puerto Rico, yielded no tephritid fruit fly larvae or pupae. Exposing ripe litchi and rambutan fruit to 12-day-old females did not result in viable fruit fly larvae. This is a robust indication that litchi and rambutan fruit exported from Puerto Rico do not pose a risk of transporting the West Indian fruit fly to trade destination countries. As a result of this research, USDA-APHIS has changed its policies on the eligibility of exporting rambutan from Puerto Rico, thus benefitting fruit growers there. (Project No. 6635-21000-050-00D)

**Post-harvest treatment of spotted wing drosophila flies protects export markets for small fruits and berries.**

Spotted wing drosophila (SWD) is a serious threat to the production and trade of economically key specialty crops in the United States, including table grape, stone fruit, blueberry, sweet cherry, blackberry, raspberry, and

strawberry. This insect is regulated as a quarantine pest in certain countries that import fresh fruits from California. ARS researchers in Parlier, California, developed a suite of post-harvest treatments, including fumigation with phosphine, to control SWD in these commodities. These treatments including phosphine have directly resulted in the retention or expansion of export markets valued at more than \$300 million annually. (Project No. 5302-43000-037-00D)

**Asian citrus psyllid abundance declines with elevation.**

The Asian citrus psyllid (ACP) transmits huanglongbing, or citrus greening, the most devastating disease of citrus in the world. Anecdotal reports indicate that ACP becomes less abundant as elevation increases. ARS researchers in Mayaguez, Puerto Rico, tested that hypothesis by monitoring ACP populations in citrus orchards at 17 different elevation sites (between 10 and 880 meters above sea level). No ACP was detected above 600 meters. Results provided strong evidence that ACP abundance declines with elevation. Identifying the factors affecting the geographical and ecological distribution of psyllid populations could help develop management strategies for the insect and the disease it spreads. (Project No. 6635-21000-055-00D)

**A Universal Plant Virus Microarray (UVPM) for the detection & identification of all known plant viruses.**

ARS scientists in Beltsville, Maryland, have built upon existing disease classification systems to develop a Universal Plant Virus Microarray (UVPM) that recognizes all known plant viruses. This virus detection microarray contains DNA material collected from 9,556 individual virus-specific probes, and was validated for at least 44 plant virus genera and taxonomic groups representing at least 15 virus families. In addition, the correct genus was identified for two recently-described viruses not represented by species-specific probes. This new assay will be especially valuable for detecting viruses in imported plants to the United States. (Project No. 1230-22000-032-00D)

**Plumbing systems identified as a common source for fungi that infect humans.**

Life-threatening infections caused by *Fusarium* fungi have increased dramatically during the last 30 years. ARS researchers in Peoria, Illinois, and their collaborators applied genetic analyses to examine the occurrence of a *Fusarium* species that is often a primary cause of those infections. They found that plumbing systems are a common source for that species. This finding can help minimize the risks from such fungal infections by contributing to more effective infection-control programs in hospitals and other settings that house individuals at risk for fungal infections. (Project No. 3620-22410-016-00D).

**Identification of fungicide resistance in the sugarbeet pathogen powdery mildew.**

In the western United States, sugarbeet yields can be reduced by fungal infections of powdery mildew. The quinone outside inhibitor (QoI) class of fungicides is typically used to control powdery mildew, but in some experimental plots near Parma, Idaho, researchers noted a reduction in its efficacy. ARS scientists in Fargo, North Dakota, and industry plant pathologists made the first-ever determination of QoI resistance in powdery mildew in the United States. They also identified a specific gene mutation in all QoI-resistant strains of the fungus, a discovery that provides the foundation for using molecular-based techniques to identify QoI-resistance. These findings will enhance efforts to manage fungicide resistance in sugarbeet production and support efforts to optimize fungicide rotations for effective disease control. (Project No. 5442-22000-047-00D)

**Discovery of a major group of beneficial nematodes.**

Although many nematodes cause significant crop losses, other species feeding on fungi or other microorganisms are beneficial to agriculture. One major agricultural problem is that the beneficial species of nematodes that might be used as biological control are often unknown. ARS scientists in Beltsville, Maryland, in collaboration with scientists from England, described six new species of nematodes (called *Rugoster* species) associated with rice, weeds, and forests in Nigeria, Ivory Coast, India, and Australia. They also developed a new diagnostic key for identifying these nematodes and related species. This key can help scientists advance the use of beneficial nematodes in agricultural soils. (Project No. 1245-22000-275-00D)

**Protecting wheat from cereal cyst nematodes.**

Cyst nematodes are among several types of plant-parasitic nematodes that reduce yields in dryland wheat fields in the Pacific Northwest and cause over \$50 million in annual losses. There are no chemical controls or resistant varieties to control this emerging pathogen. ARS scientists at Pullman, Washington, screened locally adapted germplasm and varieties for resistance in infested fields, and optimized a greenhouse screening technique for resistance. Using these new methods, they were able to successfully identify resistant wheat varieties that can be immediately grown by producers to avoid nematode losses. Wheat breeders can now use these new screening methods to develop improved varieties with even better nematode protection. (Project No. 5348-22000-016-00D)

**New technology provides nematode resistance in potatoes.**

Potato cyst nematodes (PCNs) are devastating pests impacting the U.S. potato production which is valued at \$4 billion. Methods for effective PCN control are limited and often rely on toxic chemicals so there is a major need to develop new methods to protect potatoes from these nematodes. ARS researchers in Ithaca, New York, have identified genes critical for nematode infection. They have employed a plant mediated RNAi technology to silence these nematode genes, which resulted in the development of a nematode resistant potato cultivar. This technology, which was patented, provides a valuable new tool for plant researchers working to protect potato growers and the industry from costly nematode losses. (Project No. 1907-22000-021-00D)

**Methyl bromide alternative developed for walnut planting.**

Just before walnut orchards are planted, soil fumigation with methyl bromide has been used to reduce walnut diseases caused by soil parasites and pathogens. The phase-out of methyl bromide has created a need for alternative fumigants. In an 8-year (ongoing) walnut replant trial in the San Joaquin Valley, University of California and ARS scientists determined that 1,3-dichloropropene and 1,3-dichloropropene plus chloropicrin were effective methyl bromide alternatives through the time period monitored which included 1 year of harvestable yield. First year yield was roughly doubled by optimized combinations of the alternatives. Also, the trial identified two rootstocks that perform better in a replanted orchard than the current commercial standard. The data from the trial will help walnut orchard managers to optimize their replanting decisions in the absence of methyl bromide. (Project No. 0500-00044-030-00D)

**Mobility of immature, invasive brown marmorated stink bug affects their dispersal capacity.**

Understanding the dispersal biology of brown marmorated stink bug (BMSB) at all life stages is critical for the development of site and crop-specific monitoring and management programs. Laboratory trials conducted by ARS scientists in Kearneysville, West Virginia, demonstrated that immature BMSB (i.e., those in the second through fifth nymphal stages or instars) have strong walking capacity on horizontal and vertical surfaces. Furthermore, mark-recapture studies demonstrate that BMSB nymphs can be successfully recaptured by pyramid traps baited with pheromone-based stimuli. Strong dispersal capacity of nymphs, coupled with their response to olfactory stimuli, yielded a recapture rate of up to 60 percent within 12 hours, during which insects walked farther than 20 meters on grassy ground. The results of this study indicate that BMSB nymphs have strong dispersal capacity, and that seasonal movement patterns of BMSB nymphal populations are an important component of a site-specific management program. (Project No. 1931-21000-019-00D)

**New introductions of the brown marmorated stink bug and progress in developing an improved lure for monitoring the insect.**

The brown marmorated stink bug is an invasive insect pest that causes damage in a wide variety of U.S. fruit and vegetable crops. Scientists previously thought the occurrence of the bug was due to a single introduction into the United States. However, ARS researchers in Newark, Delaware, and Montpellier, France, used genetic tools to show that brown marmorated stink bug populations in California, Oregon, and Washington were different from populations in the Northeast, which indicated that local populations resulted from different introductions. This research demonstrates the continued need for inspecting imported products for invasive pests. These new detections, as well as treatment schedules, will be aided by work of ARS researchers in Beltsville, Maryland, and Kearneysville, West Virginia, to develop an effective chemical lure. (Project Nos. 1245-22000-272-00D and 1926-22000-026-00D)

**No-till systems are helping producers restore soil health.**

Weed control is a major component of any crop production system. ARS scientists in Brookings, South Dakota, found that no-till production aids weed management because no-till leaves weed seeds on the soil surface, where their viability is rapidly reduced. Acting on these research results, no-till producers using rotations comprised of a diversity of crops are managing weeds with 50 percent less inputs compared with conventional systems involving tillage, and 1- or 2-crop rotations. In some diverse rotations, no-till producers have eliminated the need for in-crop herbicides in 75 percent of their crops, which reduces production costs and pesticide use. (Project No. 5447-21220-005-00D)

**Herbicide rotations found to be a poor strategy for preventing herbicide resistance in agricultural weeds.**

Weeds are evolving to become more herbicide-resistant, a trend that is threatening crop production and raising food costs. An analysis by ARS researchers in Urbana, Illinois, of over 500 site-years of empirical data provided compelling evidence that herbicide rotation management—a strategy that is commonly recommended to growers to delay or prevent herbicide resistance—is not only ineffective, but may actually exacerbate the problem. In contrast, this work highlights the importance of using single applications of chemically complex herbicides as a short-term method to forestall herbicide resistance while highly diversified weed management practices are established for long-term sustainable management. This finding provides new information that can be used by producers and custom applicators in designing the chemical control component of weed management programs. (Project No. 3611-12220-008-00D)

**Method developed to remotely identify herbicide-resistant Palmer amaranth.**

Palmer amaranth is a troublesome agronomic weed in the southern United States, and several populations have evolved resistance to the herbicide glyphosate. ARS researchers in Stoneville, Mississippi, developed methods to identify glyphosate-resistant and glyphosate-sensitive Palmer amaranth plants based on their spectral images from photographs. Glyphosate-sensitive plants have higher light reflectance in the visible light region and lower light reflectance in the infrared region of the light spectrum, which is invisible to the human eye. Fourteen wavebands of the photospectrum provided a classification system that could identify glyphosate-sensitive and -resistant plants with an accuracy rate of 94 percent for greenhouse-grown plants and 96 percent for field-grown plants. These results demonstrate that researchers can use hyperspectral imaging to identify glyphosate-resistant Palmer amaranth plants remotely without incurring the expense of using glyphosate. (Project No. 6402-21000-050-00D)

**Herbicide options for weed control in edamame.**

The nutraceutical food known as edamame, which is vegetable soybean, has become popular with Americans, but much of the product consumed in the United States is imported. U.S. vegetable farmers are reluctant to cultivate edamame because weed competition can severely lower crop yields and there are few herbicides registered for weed control. In fact, 4 years ago only a single herbicide was registered for edamame use. However, based in part on the work of ARS researchers in Urbana, Illinois, seven herbicides representing six modes of action are now available for use by farmers to grow edamame. This work supports U. S. growers who are looking for new options for producing marketable crop commodities. (Project No. 0500-00007-091-00D)

**Protection and preservation of bee germplasm.**

A decline in the numbers of managed honey bee colonies worldwide as well as in the populations of many indigenous bee pollinators has created an urgent need for germplasm preservation methods for honey bees and solitary bees. ARS researchers in Fargo, North Dakota, in collaboration with researchers at North Dakota State University, have developed a technique for the cryopreservation of honey bee sperm that yields 100 percent survival of the sperm after thawing. This technique will enable the conservation of not only honey bee genetic diversity, but also that of other bee pollinators, and will be used by customers and stakeholders in the honey bee and solitary bee industry to maintain genetic diversity and preserve species. (Project No. 5442-21220-027-00D)

**Honey bee protein supplements not as good as natural pollen.**

In addition to the parasites and pathogens that attack honey bees, poor nutrition adds to honey bee stress and is thought to be a contributing factor to colony decline. When pollen, a source of honey bee nutrition, cannot be

collected due to the absence of flowering plants, beekeepers will often feed their honey bee colonies a protein supplement. ARS scientists in Tucson, Arizona, demonstrated that these supplements have less protein than pollen and that honey bees do not digest them well. Furthermore, bees in colonies fed protein supplements experienced a higher incidence of disease and queen loss and, overall, had higher mortality than colonies that consumed pollen. These findings underscore the need to supply bees with pollen. This information will be used by beekeepers and extension agents working with honey bees to ensure colonies are receiving proper nutrition. (Project No. 5342-21000-018-00D)

**Chemicals and pathogens that affect honey bees.**

The honey bee is a beneficial insect because it pollinates crops with an added value of more than \$15 billion, and produces honey for human consumption. The health of honey bee colonies is jeopardized by numerous parasites and pathogens, and by insecticides and herbicides the bees come in contact with during foraging. ARS scientists in Beltsville, Maryland, found that diverse chemicals applied to agricultural crops accumulated in beeswax, honey, and in the bees themselves, and levels of one fungicide in particular (chlorothalonil) were shown to be correlated with lack of overall colony health, including susceptibility to the fungus *Nosema ceranae*. These results provide new information that can be assessed by beekeepers, extension agents, agrochemical companies, and regulatory officials interested in honey bee health. (Project No. 1245-21000-277-00D)

**Evaluation of honey production by mite-resistant honey bees.**

Among the parasites that attack honey bees, the *Varroa* mite is considered the most damaging and the biggest threat to bee colony survival. In Montana, Russian honey bees, which are resistant to *Varroa*, were evaluated over a 2-year period for honey production and mite infestation, and compared with non-resistant honey bee lines. The ARS scientists in Baton Rouge, Louisiana, who oversaw the study, reported that although the Russian bees produced less honey per colony (127 pounds) in the second year of the study than the non-resistant honey bees (162 pounds), they still produced more honey than the 60 to 90 pounds per colony reported nationally in the last few years. Importantly, Russian bees had fewer mites compared with the colony-threatening levels of mites found in the non-resistant honey bees. This research also shows that mite-resistant honey bees function well under commercial honey-producing conditions. (Project No. 6413-21000-014-00D)

**Nest attractant developed for the blue orchard bee.**

The blue orchard bee is a bee species native to North America that can be used as a pollinator of several commercial crops, including almonds, a multi-billion dollar industry. ARS scientists in Logan, Utah, and Fargo, North Dakota, in collaboration with a pollination company in California identified a chemical that attracted blue orchard bees to artificial nesting materials, which led to better nest establishment and better management of bee colonies. A patent has been filed for the chemical attractant and the information from the finding can now be evaluated by researchers who use native bees in almond pollination. (Project No. 5428-21000-015-00D)

**Greenhouse tomatoes benefit from bumble bee pollination.**

The bumble bee is a solitary bee species native to the United States. ARS scientists in Logan, Utah, evaluated the ability of different species of bumble bees to pollinate tomatoes grown in greenhouses. They discovered that not only were all species equally effective pollinators, but that tomato plants pollinated by bumble bees produced tomatoes that were 13 percent larger than plants with no access to the bees. This information will allow bumble bee producers to better focus their efforts and greenhouse tomato producers to consider the benefits of using bumble bees as pollinators. (Project No. 5428-21000-015-00D)

**Female alkali bees must eat pollen.**

The alkali bee is a ground-nesting solitary bee native to the western United States, and is a pollinator of alfalfa. ARS scientists in Logan, Utah, in collaboration with scientists in Washington State, showed that female alkali bees ate pollen at the end of each day, after they had collected nectar and pollen for rearing their offspring. The researchers extended this study to show that a species of mason bee needed to eat pollen to develop mature eggs. This information is useful to individuals and organizations that rear solitary bees for pollination services. (Project No. 5428-21000-015-00D)

**Analysis of bacteria associated with honey bee pollen and nectar collectors.**

The honey bee is an important insect pollinator of many agricultural crops. In an effort to improve honey bee nutrition, ARS scientists in Tucson, Arizona, catalogued the bacteria found in foraging honey bees that collected pollen and nectar. Genetic analyses of these bacteria are ongoing and will provide essential information to scientists researching honey bee nutrition. (Project No. 5324-21000-017-00D)



## **PLANT GERMPLASM AND CULTIVAR RELEASES**

ARS scientists have a long and successful history of genetic improvement of plants. For some crops, ARS conducts cultivar development programs and releases finished cultivars. For other crops, ARS researchers produce superior breeding lines that are released and used by public and private plant breeders to create new cultivars. ARS also distributes unimproved plant genetic resources (germplasm).

**New cultivars and enhanced germplasm.**

ARS released 50 new cultivars and breeding lines. These releases included the following crops: peanut, pea, potato, carrot, lettuce, mustard greens, cucumber, watermelon, raspberry, blackberry, blueberry, apricot, plum, apple root stocks, hops, soybean, wheat, triticale, barley, sorghum, oil sunflower, pearl millet, cotton, pennycress, prairie clover, Bermuda grass, meadow fescue, and bluebunch wheatgrass.

**Release of new apple rootstock with tolerance to apple replant disease.**

Diseases affecting U.S. apple crops have been affecting yields and profits. ARS and Cornell University researchers in Geneva, New York, have developed and released a new apple rootstock, named G.814, a dwarfing, productive, early bearing, and highly yield-efficient tree. It is the most recent product from a series of disease-resistant and productive apple rootstocks developed by the Geneva breeding program. This rootstock is resistant to fire blight and crown rot, two serious diseases that infect apple trees with serious economic consequences. Most importantly, G.814 has shown tolerance to the apple replant disease complex. This rootstock was tested for 15 years to evaluate rootstock productivity levels and compared with standard cultivars. On the basis of preliminary trials in the United States, G.814 will increase production of larger, high-quality fruit in marginal replanted orchard land, which will help apple producers increase yields and profits. (Project No. 1910-21000-026-00D)

**EPA amends the registration of ‘HoneySweet’ biotech plum, thus clearing the way for a public release.**

Sharka disease, which is caused by the plum pox virus, has devastated stone fruit production (plum, peach, cherry, and almond) in Europe and periodically threatens the United States. There is no known source of natural genetic resistance to Sharka. When outbreaks are discovered in North America diseased trees are eradicated by removal at great cost. ARS scientists in Kearneysville, West Virginia, have developed a biotech plum called ‘HoneySweet’ that is resistant to Sharka. EPA approved an amendment to the registration of ‘HoneySweet’ that will require ARS, but not nurserymen or ‘HoneySweet’ growers, to be responsible for registering, keeping

records, and reporting production of 'HoneySweet' to the EPA. This agreement provides a way forward for ARS to officially release C5 'HoneySweet' plum as an option for plum growers facing a severe outbreak of Sharka disease. (Project No. 1931-21000-023-00D)

**New soybean cultivar JTN-5110 has resistance to multiple pathogens.**

In the United States, combined soybean yield losses from the soybean cyst nematode (SCN) and several damaging fungal diseases (charcoal rot, stem canker, sudden death syndrome, and Frogeye leaf spot) are estimated to be nearly \$1 billion. Although soybean cultivars with SCN resistance have stabilized some yield losses, nematode populations have evolved that are now able to infest the resistant cultivars. ARS researchers in Jackson, Tennessee, developed and released a new soybean line, JTN-5110, that yields from 62 to 66 bushels/acre and has resistance to SCN and the fungal diseases. Growers have been anticipating a cultivar with these combined traits and are adopting the new release for more effective SCN management. This release also is being used by soybean breeders as an excellent parent material in developing more desirable cultivars. (Project No. 6402-21220-011-00D)

**The release of 'Huckleberry Gold', a new nematode-resistant potato cultivar.**

The potato cyst nematode (PCN) is increasingly responsible for economic losses in the U.S. potato industry, and the most effective and environmentally sound approach for controlling the PCN is improving host resistance. ARS researchers in Ithaca, New York, in collaboration with potato breeders at Aberdeen, Idaho, have developed Huckleberry Gold, a specialty market potato cultivar with resistance to PCN and potato virus X. Potato producers can use this new resistant cultivar to reduce losses associated with the PCN and support eradication efforts in the United States. (Project No. 1907-22000-021-00D)

**Sorghum multi-seeded mutants increase seed yield.**

ARS researchers in Lubbock, Texas, and Ithaca, New York, identified multi-seeded mutants and related genes with more primary and secondary flowering branches. These have been incorporated into higher yielding sorghum germplasm lines. These discoveries are now enabling public and private sector sorghum breeders to exploit the germplasm lines and related molecular markers to develop new varieties with substantially increased sorghum yields. (Project No. 6208-21000-01700D)

**New yield genes from a soybean wild relative found in the USDA soybean collection.** The narrow genetic base of the soybean crop limits progress in developing higher yielding varieties. ARS scientists in Urbana, Illinois, discovered and transferred into cultivated soybean unique yield genes from *Glycine tomentella* (a very distant, perennial relative of soybean). These two species are so genetically different that direct progeny from these crosses are sterile, and special procedures, including several backcrosses to the soybean parent, were needed to produce fertile progeny. Each new plant from these crosses is likely to have a different complement of *G. tomentella* chromosomes and could be genetically quite different. In tests at seven locations across four states, 10 lines were identified that yielded significantly more than the commercial soybean parent—as much as by 7 bushels/acre. This is the first report of soybean lines derived from perennial *G. tomentella*. Increasing yield is the most important objective for soybean breeders, and the genes to increase yield that were transferred from *G. tomentella* are now available to soybean breeders for the first time. (Project No. 3611-21000-026-00D)

**New Hessian fly resistance gene identified in wheat.**

Hessian fly populations have become virulent to most resistant wheat varieties grown in the southeastern United States. ARS researchers in West Lafayette, Indiana, worked with collaborators at Purdue University to identify a new resistance gene called H33 and moved it from a wheat relative into cultivated bread wheat. The H33 gene was shown to provide effective protection of wheat against Hessian fly attack in the southeastern United States. Molecular markers were identified to aid in moving this resistance gene into wheat cultivars through marker-assisted selection. Knowledge from this study will help wheat breeders prevent yield loss due to Hessian fly attack. (Project No. 3602-22000-018-00D)

**A new common bean with tolerance to low soil fertility.**

Inadequate soil fertility, high costs of fertilizers, and root rots are common crop production constraints worldwide. TARS-LFR1, a multiple disease-resistant common bean with superior performance in low-nitrogen soils and with root rot resistance was developed via collaboration among researchers with ARS in Mayagüez, Puerto Rico, the University of Puerto Rico, and Cornell University. In addition to root rot, this germplasm has resistance to common bacterial blight and Bean common mosaic virus, and it yields well in association with rhizobia through biological nitrogen fixation. This combination of traits will be valuable for plant breeders who seek to target low-input and organic production systems, in which little to no fertilizer is applied. (Project No. 6635-21000-054-00D)

**New switchgrass hybrid expands opportunities in northern climates and marginal environments.**

Switchgrass is one of the leading candidates for bioenergy feedstock production, especially in marginal environments where field crops are neither profitable nor sustainable. However, many of those marginal lands are in the more northern USDA Hardiness Zones 3 and 4 where switchgrass is not as productive as it is in the more southern Hardiness Zones 5 and 6. Recent field experiments by ARS scientists in Madison, Wisconsin, demonstrated that biomass yields in Zones 3 and 4 can be increased and competitive to those grown in Zones 5 and 6 through directed selection and breeding for high biomass yield and winter survival following harsh winters. The greatest gains in biomass yield, up to a 50 percent increase, were achieved with hybrid switchgrass that combined the high yield of a southern strain with the winter hardiness of a northern strain. This research provides the first documentation that high-yielding switchgrass strains can be productive in Hardiness Zones 3 and 4. (Project No. 3655-21000-05600D)

**New sand bluestem forage variety released for the arid Southern Plains Region.**

Under field conditions, soil moisture is often inadequate for the satisfactory establishment of native grass seedlings. These dry soil conditions limit a range land manager's ability to reestablish native grasses after a disturbance, such as drought or energy exploration. ARS scientists in Woodward, Oklahoma, in cooperation with the NRCS in Knox City, Texas, and Manhattan, Kansas, have developed a variety of sand bluestem (a native, perennial, warm season bunch grass) that has superior field emergence and plant density when planted in dry soil conditions. The new variety, named "Centennial," was developed using traditional breeding techniques, and is expected to help increase establishment success with its improved seed germination under dry soil conditions. This variety has demonstrated increased emergence and 17 percent higher plant density compared to other varieties, providing range land managers another viable option when attempting to establish native grasses on disturbed lands. (Project No. 6216-21630-010-00D)

**Unenhanced plant germplasm distribution.**

The National Genetic Resources Program (NGRP) is responsible for acquiring, characterizing, preserving, documenting and distributing to scientist, germplasm of all life forms important for food and agricultural Production. In CY 2014, 255,402 plants or seeds were distributed. The table below lists the number of distributions from the NGRP repositories in the Germplasm Resources Information Network (GRIN) to different organizational categories for CY 2014.

**Organization Categories Key:** FCOM=Foreign commercial company, FGEN=Foreign genebank/resources unit, FIND=Foreign individual no affiliation, FPRU=Foreign non-commercial organization, INT=CGIAR International Agr. Res. Center, STA=U.S. state agencies and all universities, UARS=Agricultural Research Service, UCOM=U.S. commercial company, UFED=U.S. Federal agency (not ARS or AID), UNID=U.S. individual no affiliation, and UPRU=U.S. non-profit organization.

**Repositories Key:** COR=Natl. Germplasm Repository- Corvallis, COT=Cotton Collection, DAV=Natl. Germplasm Repository- Davis, GEN=Natl. Germplasm Repository- Geneva, GSOR=Rice Genetic Stock Center, GSPI=Pea Genetic Stock Collection, HILO=Natl. Germplasm Repository- Hilo, MAY=Natl. Germplasm Repository- Mayaguez, MIA=Natl. Germplasm Repository- Miami, NC7=North Central

## Annual Reporting on Technology Transfer in USDA, FY 2015

Regional PI Station, NE9=Northeast Regional PI Station, NR6=Potato Germplasm Introduction Station, NSGC=National Small Grains Collection, NSSL=National Center for Genetic Resources Preservation, NTSL=Forest Service National Seed Lab, OPGC=Ornamental Plant Germplasm Center, PARL=National Arid Land Plant Genetic Resources Unit, RIV=Natl. Germplasm Repository- Riverside, S9=Southern Regional PI Station, SOY=Soybean Collection, and W6=Western Regional PI Station.

SITE	UAR S	UFE D	STA	UCO M	UPR U	UIND	UAID	INT	FGE N	FCO M	FPRU	FIND	Totals
<b>COR</b>	760	26	1141	1023	194	3456	0	0	326	147	423	<b>74</b>	7570
<b>COT</b>	0	0	59	10	5	28	0	0	0	0	0	<b>1</b>	103
<b>DAV</b>	231	5	1023	1070	270	4971	0	0	138	9	128	<b>30</b>	7875
<b>GEN</b>	2005	18	637	591	262	2565	0	0	0	4	99	<b>90</b>	6271
<b>GSO</b>													
<b>R</b>	1777	1	3895	223	250	49	0	0	3	104	5331	<b>5</b>	11638
<b>GSPI</b>	13	0	64	4	0	8	0	0	5	7	185	<b>26</b>	312
<b>HILO</b>	63	0	28	29	12	82	0	0	0	22	0	<b>0</b>	236
<b>MAY</b>	25	16	57	42	42	147	0	0	81	0	1	<b>6</b>	417
<b>MIA</b>	77	0	205	41	19	64	0	0	0	0	22	<b>0</b>	428
<b>NC7</b>	2390	8	10319	8460	982	1862	0	349	83	6904	11274	<b>132</b>	42763
<b>NE9</b>	70	5	2123	1254	198	316	0	0	0	1493	634	<b>48</b>	6141
<b>NR6</b>	1651	13	1342	1812	138	365	0	0	1	30	178	<b>29</b>	5559
<b>NSG</b>													
<b>C</b>	15338	5	21691	3032	148	1202	0	44	1014	729	21507	<b>121</b>	64831
<b>NSSL</b>	97	0	56	7	4	5	0	0	3	33	13	<b>27</b>	245
<b>NTSL</b>	865	1	0	0	0	0	0	0	0	0	0	<b>0</b>	866
<b>OPG</b>													
<b>C</b>	9	0	140	73	23	141	0	0	0	135	37	<b>3</b>	561
<b>PARL</b>	18	0	208	291	117	239	0	0	22	19	43	<b>2</b>	959
<b>RIV</b>	123	0	110	2	30	37	0	0	32	3	170	<b>27</b>	534
<b>S9</b>	3228	5	16374	3843	339	818	0	1	1223	4932	3982	<b>139</b>	34884
<b>SOY</b>	4118	2	13858	8083	270	262	0	0	1684	241	746	<b>0</b>	29264
<b>W6</b>	3125	67	9163	1931	1012	3914	0	2044	1318	599	10001	<b>771</b>	33945



## NATIONAL AGRICULTURAL LIBRARY

The National Agricultural Library (NAL) is one of the largest and most accessible agricultural research libraries in the world. NAL provides services directly to the staff of USDA and to the public, primarily via the NAL Web site, <http://www.nal.usda.gov>. NAL was formed with USDA in 1862 and was named in 1962 a national library by Congress, as “the primary agricultural information resource of the United States.” NAL is the premier library for collecting, managing, and disseminating agricultural knowledge. The Library is the repository of the Nation’s agricultural heritage, the provider of world class information, and the wellspring for generating new fundamental knowledge and advancing scientific discovery. It is a priceless national resource that, through its services, programs, information products, and Web-based tools and technologies, serves anyone who needs agricultural information. The Library’s vision is “advancing access to global information for agriculture.”

### **PubAg.**

PubAg is a portal to USDA-authored and other highly relevant agricultural research. At launch in 2014, PubAg delivered over 41,892 full-text journal articles by USDA staff and included nearly 1,011,937 citations. NAL is adding about 20,000 citations each month. PubAg also provides access to 340,000 peer reviewed, agriculture-related scientific articles, published primarily between 2002 and 2012. Each article citation in PubAg includes an abstract, NAL Thesaurus subject terms, and a link to the article if available from the publisher. PubAg can be found at <http://PubAg.nal.usda.gov>.

### **DigiTop.**

NAL obtained contributions from across USDA to purchase licensed full text databases to support research and scientific discovery. Just over two years ago, NAL launched a new component of DigiTop, called Navigator, that enables cross searching of multiple bibliographic databases. This system includes AGRICOLA, AGRIS, BIOSIS, CAB Abstracts, Fish, Fisheries & Aquatic Biodiversity Worldwide, Food Science and Technology Abstracts, GEOBASE, GeoRef, MEDLINE, Wildlife & Ecology Studies Worldwide, Scopus, and Zoological Record. The Navigator service allows researchers to access nearly 79 million records at once and is updated weekly.

### **Automated indexing.**

NAL is continuously improving full scale production—automated indexing/text analytics software to generate the AGRICOLA Index of agricultural literature. This application combines semantic analysis, machine learning, and human constructed rules to automatically assign NAL Thesaurus subject terms to journal article citations. This metadata facilitates effective literature classification, management, search, and retrieval.

### **Digitization of NAL collections.**

NAL is in the midst of a large scale digitization project to digitize agricultural literature and provide online access to the general public. Important and distinctive items were selected from the NAL collection, with an initial focus

on USDA issued publications and nursery and seed trade catalogs. Publications are accessible at <https://archive.org/details/usdanationalagriculturalibrary>.

### **i5K Workspace at NAL.**

NAL launched the i5K (insect 5,000 genome) Workspace (<https://i5k.nal.usda.gov/>) to meet the initiatives needs for genome hosting and other bioinformatics services. The Workspace currently hosts 35 genomes with several more in the pipeline. Approximately 200 researchers are involved in community annotation. Content is accessible via organism pages, genome browsers, and a completely updated and improved BLAST search engine, implemented via the open source Tripal framework, a Web interface for the underlying Chado database schema.

### **VIVO.**

NAL launched VIVO, a Web application used internally by USDA scientists since 2012, to allow for better national networking across disciplines and locations. USDA VIVO will be a "one-stop shop" for Federal agriculture expertise and research outcomes. This efficient networking tool enables scientists to more easily locate others with a particular expertise that may contribute to a project's success. VIVO also makes it possible to quickly identify scientific expertise to address and rapidly mobilize a response on emerging agricultural issues, such as specific plant and animal diseases or pests.

### 3.10. Outreach Activities: Workshops, Field Days & Forums



#### Arizona:

##### **Arid-Land Agricultural Research Center**

- Arid-Land Agricultural Research Center and the University of Arizona, Maricopa Agricultural Center in Maricopa co-hosted Farm Day, a community outreach event. ARS research in entomology, plant science and water management was featured using interactive displays and hands-on activities. Approximately 350 people attended from the city of Maricopa and surrounding communities, including stakeholders. (10/25/14)
- A tour of the center, the center's greenhouses and field plots were given by a scientist to visiting researcher from Rubber Technology Center, India. (10/8/14)

##### **Carl Hayden Bee Research Lab**

- Presented research on photoperiodic control of *Lygus* diapause. Approximately 500 industry, federal, and state university personnel associated with cotton were in attendance. (1/5-7/15).
- Scientists presented their research on the effects of honey bee nutrition on colony health at a commercial beekeepers meeting, research conference, and Carl Hayden Bee Research Center Laboratory Open House. Approximately 400 industry and research personnel from the American Honey Producers, American Beekeeping Federation, Apiary Inspectors of America, and American Bee Research Conference participated in the various events. (1/7,8,20-22/15)

##### **Pest Management and Biocontrol Research Unit**

- Presented research on photoperiodic control of *Lygus* diapause. Approximately 500 industry, federal, and state university personnel associated with cotton were in attendance. (1/5-7/15).
- Dr. James Hagler provided hands-on training on Insect Immunomarking. Pennsylvania State University is using the procedure Dr. Hagler developed to track insect dispersal patterns in an agroecosystem. Ohio State University plans to use the method to track bed bug dispersal patterns in urban landscapes. (3/2-6/15, 7/21-22/15)

##### **Plant Physiology and Genetics Unit**

- Participated in the 5th AgMIP Global meeting to promote collaborative research on potential impacts of climate

change on agriculture. Approximately 300 international scientists with expertise in economics, climatology, data management and crop production participated. (2/25-28/15)

- Presented the approach used by the Agricultural Model Intercomparison and Improvement Project (AgMIP) for documenting field research at the "Improving Semantics in Agriculture" Workshop held at the Food and Agriculture Organization of the United Nations, Rome, Italy to assess opportunities for improved management of data from agricultural research and development efforts. Approximately 60 researchers, which included development specialists from diverse institutions in Europe, South America and Africa, and information management specialists attended. (7/2-3/15)
- Presented work on guayule production and breeding in Arizona during the 2015 School of Plant Sciences Research Retreat. University professors, directors, and researchers were in attendance.
- Experimental data on the response of wheat to a wide range of temperatures obtained by varying planting date and infrared heating were furnished to wheat growth modelers for the purpose of testing the high temperature aspects of their models. This information has been distributed widely to University of Arizona and other academic researchers. (3/25/15, 5/1/15, 8/4/15)
- Presented/discussed with Microsoft Computational Research Laboratory, Cambridge, UK, the effects of elevated CO<sub>2</sub> on cotton, wheat and sorghum, resulting from free-air CO<sub>2</sub> enrichment (FACE) experiments. The data will be used in validation test of crop growth models used to predict likely effects of global change on future crop productivity. (1/28/15)
- In an effort to improve the response of wheat growth models to high CO<sub>2</sub> concentrations, such as anticipated in the future, as well as drought and low nitrogen, ARS scientists from the Plant Physiology and Genetics Research unit and the University of Arizona furnished a wheat dataset from wheat that had been grown at elevated CO<sub>2</sub> concentrations and at ample and limited supplies of water and nitrogen. University of Bonn, Germany received the information and will distribute the data to at least eight other scientists at institutions around the world. (5/7/15)

### Southwest Watershed Research Center

- In an effort to improve the response of wheat growth models to high CO<sub>2</sub> concentrations, such as anticipated in the future, as well as drought and low nitrogen, ARS scientists from the Plant Physiology and Genetics Research unit and the University of Arizona furnished a wheat dataset from wheat that had been grown at elevated CO<sub>2</sub> concentrations and at ample and limited supplies of water and nitrogen. University of Bonn, Germany received the information and will distribute the data to at least eight other scientists at institutions around the world. (5/7/15)
- Dave Goodrich, Mark Nearing, and unit staff presented a two-day workshop to 30 participants including action agencies, consultants, and students on the Automated Geospatial Watershed Assessment (AGWA) tool and the Rangeland Hydrology and Erosion Model (RHEM). (3/18-19/15)

### Water Management and Conservation Research Unit

- Two scientists met with a Cotton Incorporated representative to discuss research on mitigation of nitrous oxide emissions from cotton and guayule, and high throughput cotton phenotyping plans for 2015. (12/2/14)
- Scientists in the Plant Physiology & Genetics Research Unit and the Water Management & Conservation Research Unit; in collaboration with the University of Arizona, Kansas State University, and private industry; conducted a four-day workshop to introduce researchers to basic principles of field-based high throughput phenotyping. Approximately 50 grad students, researchers and private company personnel participated.
- Provided an update of nitrogen budgets for surface and sprinkler irrigation management approaches for southwest cotton. Data was presented to 120 industry consultants and cotton producers from Arizona, California, Idaho, and Utah. (3/5/15)
- Participated in the Pakistan Water Dialogue. The Dialogue is an initiative led by USDA Foreign Agricultural Service (FAS) and the Pakistan office of the International Water Management Institute (IWMI). The scientist provided information on technology for hydraulic modeling of surface irrigation systems, as well as conducting a one day training workshop on the use of the WinSRFR software to staff of the IWMI and various Pakistani irrigation management organizations. Participated in a debriefing meeting with US Embassy staff (USAID/ASSIST/State Department) to discuss USDA activities in Pakistan related to improved irrigation water management. (2/10-13/15)
- Presented a seminar titled: "Current developments in the hydraulic analysis of surface irrigation systems," at the University of Arizona, Agricultural and Biosystems Department, Tucson AZ. The meeting provided an overview of surface irrigation software and allowed discussion of components currently under development that will enhance

analytical capabilities for practical and research users. (10/13/14)

- Scientists presented information on the design of a drip irrigation system and how it is operated and managed to grow crops. Interested farmers are planning to develop a 20-acre organic vegetable farm in urban South Phoenix area. County Extension personnel and private farmers participated. (6/30/15)

### **Water Management and Conservation Research Unit/ Plant Physiology and Genetic Research Unit**

- One scientist from the Plant Physiology and Genetics Unit and two scientists from the Water Management and Conservation Unit presented approaches for field-based phenotyping at a workshop at Texas A&M University located in College Station, Texas. Approximately 200 researchers, graduate students and private company personnel attended the event and webinar broadcast. (10/17-18/14)
- Scientists and engineers from USDA-ARS, University of Arizona Yuma Center of Excellence for Desert Agriculture and nMode Solutions of Tucson evaluated the potential technologies to scan plant roots in situ using magnetic resonance imaging. ARS scientists described research on imaging roots of cotton, melon, and sorghum. (9/17/14)

### **Arkansas:**

#### **Dale Bumpers National Rice Research Center**

- Dale Bumpers National Rice Research Center, co-hosted with the USA Rice Federation, a tour of the facilities and an overview of research conducted at the center to a delegation from The Philippines, including their Deputy Secretary of Agriculture and will include visits with state government representative and tours of local rice mills and rice farming operations. (6/22/2015)

#### **Delta Watershed Research Unit**

- ARS Delta Watershed Research Unit in Jonesboro, AR hosted a meeting with colleagues from the University of Arkansas to discuss edge of field data collection strategies and challenges. (3/5-6/2015)

### **Brazil:**

#### **Animal Genomics and Improvement Laboratory**

- Presented (by invitation) a talk on Animal Genomics and Improvement Laboratory research at the 52nd meeting of the Brazilian Society for Animal Science in Belo Horizonte (7/20-23/2015)
- Presented (by invitation) a talk on Animal Genomics and Improvement Laboratory programs to staff of the Holstein Association of Minas Gerais State (7/22/2015)

### **California:**

#### **Exotic and Invasive Weed Research Unit**

- Organized a three-part aquatic weed management workshop for natural resource agency personnel seeking CEU credits. An overview of aquatic weed management technology was presented to approximately 520 registered attendees of the California Weed Science Society. CWSS is predominantly for agricultural practitioners, applicators, and crop consultants. (1/21/15)
- Discussed plans by the State of California, Division of Boating and Waterways (CDBW), to control aquatic weeds growing in the bays of a residential boating-oriented development and throughout the Sacramento-San Joaquin Delta. Presented research information to 200 boaters/residents on biocontrol of aquatic weeds, and discussed the role of the new USDA-ARS Area-Wide Project on Aquatic Weeds and Mosquitos in the Delta to improve control outcomes. (2/25/15)
- Reported on the objectives, goals, and progress of the USDA-ARS Areawide Pest Management Program for improved adaptive management of invasive water hyacinth, Brazilian waterweed and arundo for protection of water resources in the drought-stricken Sacramento-San Joaquin Delta. The Delta Plan Interagency Implementation Committee (DPIIC) is a California state executive committee, responsible for the implementation of the Delta Plan, a 50-year plan to achieve co-equal goals to efficiently use the water resources of the Delta and to restore Delta

ecosystems. (5/11/15)

- Provided biological life cycle information on the arundo wasp *Tetramesa romana*, a biological control agent of *Arundo donax*, a major invasive grass weed that consumes water in the drought-stricken Sacramento River Valley, and delivered arundo plants with shoot tip galls containing the wasps to three field sites along tributaries of the Sacramento River in Glenn and Butte Counties, CA. The scientist met with landowners and CSU-Chico faculty to coordinate monitoring and further wasp releases. (6/11-26/15)
- Presented on the ecology and management of flowering rush. Accompanied tribal and state / county natural resource agency personnel on a field trip to examine flowering rush infestations and discuss what might be done to manage this species before it expands too much. Approximately 50 riparian users and riverfront users, as well as natural resource agency and tribal management personnel were in attendance. (7/28/15)

### **Foodborne Toxin Detection and Prevention Research Unit**

- Presented a status report on development of a plant volatile-based attractant and proposed research for use of the attractant in pistachio orchards to board members of CPRB, growers, and other researchers. (1/22/15)

### **Healthy Processed Foods Research Unit**

- Demonstrated novel uses for food waste, and showcased commercialized products developed by ARS researched that solve this important global issue. Gorge Delights Just Fruit Bars, NewGem Foods Fruit and Vegetable Wraps, Whole Vine Products Wine Grape Flours and Oils, Whole Vine Products Cookies and T8 Veggie Chips were highlighted, as were nonfood, biodegradable utensils and plates. "Waste to Worth: Food Processing Solutions" was presented for 19,000 registered individuals at this annual event, held in Arlington, Virginia. (2/19-20/15)

### **Foodborne Toxin Detection and Prevention and Healthy Processed Foods Research and Crops, Diseases, Pests and Genetics Research Unit**

- Reported on research to sterilize navel orangeworm (NOW) using x-rays and determination of required doses and experience with NOW including rearing issues inherent to this particular insect. Representatives from California Pistachio Research Board, Almond Board of California, Western Agricultural Processors Association, California Cotton Ginners and Growers Association, ARS, APHIS, Setton Pistachio, and Wonderful Orchards (formerly Paramount Farming) were in attendance. (6/30/15)

### **Crops Pathology and Genetics Research Unit**

- Presented at the Global Alliance for Climate-Smart Agriculture session of the USDA Agricultural Outlook Forum. ARS efforts that were profiled include: GRACenet, the USDA Climate Hubs and content from the publication "Climate-Smart Agriculture Global Research Agenda: Scientific Basis for Action." Climate-Smart Agriculture technologies from USDA included the Climate Change Response Framework run by the USDA-FS Northeastern Institute for Applied Climate Science and their partners, USDA NRCS COMET-FARM to which USDA-ARS contributes data for this tool's development. Audience included the press, personnel from USDA agencies, NOAA and other US federal and state agencies, representatives from Embassies, commodity groups and agriculture industry representing national and international efforts. Approx. 150 people attended the session; >1000 people participated in the Forum. (2/19-20/15)

### **Commodity Protection and Quality Research Unit**

- Scientist presented research and methods for managing navel orangeworm (NOW) infestation at the South SJV Almond Symposium, alongside UC Cooperative Extension agents and County Ag Commissioner to an audience of individual growers, farming company personnel and university extension specialists. (5/28/15)

### **Crop Diseases, Pests and Genetics Research Unit**

- Central San Joaquin Valley table grape growers and the California Table Grape Commission were shown new

advanced table grape selections from the ARS breeding program in Parlier, CA. Both newly harvested selections, and some held in storage for two months, were on display for tasting and evaluation at the research meeting. The meeting's purpose was to provide growers with the opportunity to sample and comment on new advanced table grape selections relative to existing commercial varieties. (10/2/14)

### **Water Management Research Unit**

- Scientists from the Water Management Research Unit co-organized and presented at the 2014 Pomegranate Field Day held at University of California Kearney Ag Center. Research findings on water and nitrogen use, and tree growth parameters were reported to approximately 40 individual growers, farming company personnel, and university extension specialists. Event participants toured the research orchard. (10/2/14)
- Approximately eight growers from Maine toured the San Joaquin Valley and visited the SJVASC to learn water management practices and instrumentation for irrigation and crop water use. (2/18/15)

### Colorado:

#### **Central Great Plains Research Station**

- The Annual Spring Field Day is a combined effort with Colorado State University. Scientists present relevant information to customers attending the event. Farmers come from Kansas, Wyoming and Nebraska, lunch is sponsored by the local Ag-industry. There were 102 attendees. Stakeholders praise ARS for the event and the ideas and discussion that occur during the day. These discussions have tremendous value to ARS as a feedback mechanism with several customers/farmers who we serve.

### **Water Management Research Unit**

- The Water Management Research Unit along with Colorado State University collaborators held a joint field day at the USDA Limited Irrigation Research Farm. Sixty-three stakeholders attended representing water conservation districts, university cooperative extension, academic researcher, state and federal agencies and private industry.

### Denmark:

#### **Animal Genomics and Improvement Laboratory**

- Presented (by invitation) presentation on gut health of ruminants and Animal Genomics and Improvement Laboratory research at the 8th International Conference on Farm Animal Endocrinology (8/27/15)

### Florida:

#### **Animal Genomics and Improvement Laboratory**

- Presented papers on Animal Genomics and Improvement Laboratory research at the 2015 Interbull annual meeting in Orlando (7/9-12/2015)
- Presented talks and posters on Animal Genomics and Improvement Laboratory research at the 2015 joint annual meeting of the American Dairy Science Association and the American Society for Animal Science in Orlando (7/12-16/2015)

### Georgia:

#### **Crop Genetics and Breeding Research Unit**

- Hosted a delegation of women scientists from Pakistan, as part of the Department of State's International Visitor Leadership Program. The delegation consists of eight female scientists from various agricultural disciplines, including aquaculture, plant breeding, weed science, and agronomy. (12/3/2014)

#### **Southeast Poultry Research Laboratory**

- ARS Southeast Poultry Research Laboratory hosted a training with (APHIS) USDA, and provides field veterinarians

with current information on foreign animal diseases and preparedness for infectious disease outbreaks. (2/18-19/2015)

- Hosted the 9th International Symposium on Avian Influenza. The conference is held every 6 years in the USA and has 254 participants from 35 countries. (4/12-15/2015)

### **Southeast Fruit and Tree Nut Laboratory**

- ARS Southeastern Fruit and Tree Nut Laboratory in Byron, GA, hosted a Pecan Field Day for about 350 attendees from southeastern states. ARS pecan researchers highlighted aspects of ongoing research activities and information of relevance to pecan farmers of southeastern United States. (9/3/2015)

### **Hawaii:**

#### **Daniel K. Inouye U.S. Pacific Basin Agricultural Research Center**

- Presentation of recent research on microbial biological control of coffee berry borer to research and extension scientists and coffee growers.

#### **Tropical Crop and Commodity Protection Research and Tropical Plant Genetic Resources and Disease Research Units**

- Hosted a visit of Japanese nationals representing a government ministry, a university, a non-profit organization and a private farm. Presented research approaches to pest management including development of GE papaya and its coexistence with non GE Papaya, irradiation treatment of fruit to enable shipment out of state and country, development of pest attractants, research to improve the sterile insect technique, and the methods used to communicate with U.S. stakeholders to best serve their needs.
- The flat bark beetle *Cathartus quadricollis* is a predator of the coffee berry borer, a worldwide pest of coffee and a new pest in Hawaii. This predator can be raised on a cracked corn-cornmeal diet, and a raise and release program was started by providing farmers with a predator starter kit. Distributed >200 kits to coffee farmers.

#### **Tropical Plant Genetic Resource and Disease Research Unit**

- Spoke about the zero waste research project including increasing biomass and lipid production of algae and its potential use as fish feed to the owners of Big Island Biodiesel and state government personnel. (10/2/14)
- Lectured on techniques for controlling plant-parasitic nematode pests in nursery and floriculture operations in a presentation titled “Management of Plant-parasitic Nematodes in Nursery Production” to local growers of nursery and floriculture crops. (10/3/14)
- Gave a tour of the research projects, field and facilities and overview of the National Plant Germplasm system to a professor and 15 students from the University of Hawaii at Hilo, College of Agriculture, Forestry and Natural Resources Agribusiness class (02/09/15).
- Provided an overview of Rapid Ohio Death research going on at DKI-PBARC to US Forestry, homeowners and land management representatives. (1/13/15)
- Provided an overview of the CBB research going on at DKI-PBARC and the implementation of the Area-Wide IPM Program to coffee growers and industry representatives. (1/30/15)
- A small group of quarantine treatment researchers from tropical regions of 5 continents discussed taxonomy, trade, market access, treatment responses, and future collaborations proposed treatment approaches to control Oriental Fruit Fly (12/15/14)

#### **Tropical Crops and Commodity Protection Research Unit**

- Presented a webinar talk “Phytosanitary Irradiation for Control of Quarantine Insect Pests” to Department of Energy, Department of Homeland Security, USDA APHIS and industry representatives as part of an Alternative Technologies for Radioactive Sources Working Group meeting. The group is exploring electronic alternatives to cesium-137 and cobalt-60 research and blood irradiators. Follett discussed his plans to build a cabinet style x-ray irradiator to treat fruit for quarantine insect control and market access. (7/7/15)
- Presented research on improving the post-processing color, flavor and shelf-life of roasted macadamia kernels. About 150 growers and processors attended. (6/20/15)
- Released version 0.6 of MED-FOES (MEDfly, Outbreak and Extirpation Simulation). The new version includes a spatial component, and is available online for use by regulators and program managers around the world.

Idaho:

**Small Grains and Potato Germplasm Research**

- Presented at the Oat Rust Forum 2015 on the development of a molecular marker platform that would be capable of diagnosing oat lines for the crown rust resistance genes that they carry. Approximately 25 breeders, growers and industry representatives attended. (02/17/15)

Illinois:

**National Center for Agricultural Utilization Research, Crop Bioprotection Research Unit**

- Summary information on field work related to evaluation of low lignin sorghum lines for insect damage distributed as a handout at Central Illinois Irrigated Growers Association, Irrigation Clinic at Havana, IL. 2/5/15
- Identified and developed an attractant that is being used by farmers, land managers, and city arborists, to survey for the presence of an invasive ambrosia beetle (Polyphagous Shot Hole Borer) which is causing severe damage to avocado and urban trees in southern California. The attractant was developed with a commercial collaborator.

**National Center for Agricultural Utilization Research, Bio-oils Research Unit**

- Participated in the STLE Annual Meeting in Dallas, TX and presented three papers (authored by Bantchev et. al., Harry-O'Kuru et. al.); attended the STLE Fellows Committee meeting; and taught several modules of the "Biofuels and Biolubricants" course. 5/17-21/15

**National Center for Agricultural Utilization Research, Mycotoxin Prevention and Applied Microbiology Research Unit**

- Presentations at the 2015 Corn Dry Milling Conference including the impacts of climate change on physiology, promising applications of nanotechnology, and free vs. total toxin levels in corn. 5/14/15

Indiana:

**National Soil Erosion Research Laboratory Unit**

- Conducted a training workshop on Water Erosion Prediction Project (WEPP) model at the 10th Federal Interagency Sedimentation Conference at Reno, NV. 4/23/15

Iowa:

**Agroecosystems Management Research Unit**

- Gave invited presentation "Saturating Riparian Buffers in Tile Drained Landscapes for Nitrate Removal" at 2015 Waseca County Farmer Forum. Farmers and state agency personnel attended. 3/11/15
- Gave presentation "Field-edge practices to reduce nitrate losses to surface waters from tile-drained fields," at 2015 Summer Education Week for American Society of Farm Managers and Rural Appraisers, Omaha, NE. 7/21/15
- Presented at the Minnesota Crop Production Retailers CPM Short Courses and Trade Show, Minneapolis, MN, on using cover crops to reduce nutrient losses and to improve soil health to crop consultants and agricultural business people over two sessions. 12/10/14
- Participated in the Iowa Independent Crop Consultants Annual Meeting in Ames, IA, and presented an overview of how various soil and crop management strategies affect phosphorus, potassium, and sulfur cycling in soil and losses of these nutrients from the plant root zone. Attended by 60 Certified Crop Consultants. 2/18/15
- Participated in the North Central Industry-Extension Soil Fertility Conference in Des Moines, IA, and provided an update on current research addressing potassium availability in upper Midwest soils. Attended by 150 fertilizer industry representatives, Cooperative Extension personnel, and independent consultants from the U.S. and Canada. 11/19-20/14
- Held a two-day training session on the Agricultural Conservation Planning Framework at Mankato, MN, which was attended by 24 individuals affiliated with state and federal agencies, county government, universities, and engineering consulting firms. This software enables spatial analyses to identify where various types of conservation

practices can be placed in a watershed for water quality improvement. 8/13-14/15

### **Corn Insect and Crop Genetics Research Unit**

- Presented research to the Iowa State University CALS Deans and Center Directors in Ames, IA. Information on crop genomics, genomic databases, and Bt-corn risk assessment and resistance management was exchanged. 5/8/15

### **NADC, Infectious Bacterial Diseases Research Unit**

- Research Update on Brucellosis Studies at NADC. National Academy of Science. Jackson, WY. 9/15/15

### **NADC, Ruminant Disease and Immunology Research Center**

- Gave invited plenary talk and attended the combined meeting of the 17th Latin-American Buiatrics Conference and the 11th Brazilian Buiatrics Conference 2015 in Sao Paulo, Brazil. Spoke on impact of pestivirus variability on design and implementation of control programs to an audience that included veterinary consultants, researchers, diagnosticians and producers. 7/22-24/15

### **Plant Introduction Research Unit**

- Germplasm Enhancement of Maize (GEM) Project staff hosted the annual GEM field day at the Plant Introduction Research Unit in Ames, IA. The field plots demonstrate maize germplasm enhancement products (populations, lines and hybrids), breeding processes and technologies, and some important historical lines. 9/22-23/15

### **Soil, Water, and Air Resources Research Unit**

- Presented on limitations to agricultural use of Humic products at the annual meeting of the Humic Products Trade Association in New Orleans, LA. 12/02/14
- Presented findings on deep-pit foaming to Iowa Pork Producers Associations at Iowa Pork Congress to producer groups. Information is being used to target control strategies and used to inform producers of the dangers of foaming pits along with strategies to mitigate dangers of foaming pits. 1/28/15
- Presented information from feeding trials to a representative of Iowa Nutrient Applicators Association and ISU Agriculture Engineering group and ARS scientists on the topic of hydrogen sulfide emissions associated with pumping of manure from swine buildings. Discussed potential causes and changes in diets with high rates of sulfur inclusion from DDGS. 6/3/15

## **Kansas:**

### **Grain Quality and Structure Research Unit**

- The USDA Regional Performance Nursery consists of two nurseries: the Northern Regional Performance Nursery (NRPN) and the Southern Regional Performance Nursery (SRPN). These nurseries provide critical information to breeders on the end-use quality of experimental breeding lines and aids in the selection and screening process of variety release to the general public.
- The Annual Sorghum Improvement Conference of North America brings together stakeholders, customers and scientists across broad disciplines within the sorghum industry. The conference includes scientific presentations, tours of field plots, and informal discussions. The venue brings together scientists, producers and sorghum industry personnel to discuss the needs of the sorghum community.

### **Soil and Water Management Research Unit**

- The Ogallala Aquifer Program in an ARS led federal-state research-education consortium seeking solutions to problems arising from decreases in water availability from the aquifer. Approximately 80 participating scientists and 40 visitors/stakeholders attended part or all of the workshop. Visitors and stakeholders provided input on critical research needs that the program should be addressing. Participating scientists discussed future research plans, resulting in submission of proposed work plans for FY2016 and 2017.
- The Wheat Field Day was held in conjunction with Texas A&M AgriLife Research and Extension Service. More than 150 stakeholders, extension agents, industry and cooperators attended the event. Information was provided on new and emerging wheat varieties, and better management practices for wheat production on the Southern High Plains.

Kentucky:

**Food Animal Environmental Systems Research Unit**

- Presented at symposia targeting produce safety industry, researchers and extension agents

**Food-Animal Production Systems Research Unit**

- Presenter at the Larkspur/Tall Fescue Workshop hosted by the Meat Animal Research Center at Clay Center. Title was “The Impact of Fescue Toxicosis on Cattle Production.” 9/15/15
- Presenter at the Kentucky Small Ruminant Conference held in Russellville, KY. Spoke on the impacts of fescue toxicosis on sheep and goats. 2/7/15.

Louisiana:

**Commodity Utilization Research Unit**

- ARS SRRC Commodity Utilization Research Unit, hosted the director, staff and students of the Institute of Subtropical Forestry (ISF), Hangzhou, China summarizing recent research results in the shared field of tung tree genetics and biochemistry. Also, discussion on the results recently generated by collaborators in (ISF) studying roles of genes from tung tree -to engineer in the creation of transgenic plants with increased resistance of fungal pathogens. (10/17-24/2014)

**Honey Bee Breeding, Genetics and Physiology Research Unit**

- Honey Bee Breeding, Genetics and Physiology Research Unit, hosted three representatives of the French National Institute for Agricultural Research (INRA) and the French technical and scientific institute of beekeeping and pollination (ITSAP). The objectives of the visit are to exchange information about techniques related to selecting honey bees for resistance to Varroa mites. (6/1-6/2015)

**Sugarcane Research Unit**

- Sugarcane Research Unit, co-hosted the annual USDA-LSU AgCenter Sugarcane Field Day at the Ardoyne Research Farm in Schriever, LA. Approximately 100 people attend, including local farmers, and extension/sugar industry personnel. (6/5/2015)

Maryland:

**Animal Genomics and Improvement Laboratory**

- Presented (by invitation) a talk on Animal Genomics and Improvement Laboratory research at the 2015 ARS Big Data Workshop in Beltsville (7/16-17/2015)
- Presented (by invitation) seminar on Animal Genomics and Improvement Laboratory Research at a seminar for the Department of Animal and Avian Sciences (4/28/15)

**Environmental Microbial and Food Safety Laboratory**

- EMFSL hosted the annually recurring field trip for Food Quality Control (NFSC 431) class from the Nutrition and Food Science Department at the University of Maryland, College Park (03/06/2015)
- EMFSL hosted a visit by the Technical Adviser for Japan Association for Techno-innovation of Agriculture, Forestry and Fisheries; Executive Director of Japan Bakery Institute, and Researcher from National Food Research Institute Tsukuba (03/10/2015)
- EMFSL hosted the annually recurring visit to BARC for approximately 40 members of the National Science Teachers Association participating in FDA-sponsored professional development program (07/22/2015).
- EMFSL was included on the agenda for Dr. Deirdra Chester and Dr. Jodi Williams, NIFA national program leaders for Applied Nutrition Research and for Food Safety, during their visit to BARC and BHNRC (09/09/2015).
- EMFSL hosted the annually recurring field trip for Food Quality Control (NFSC 431) class from the Nutrition and Food Science Department at the University of Maryland, College Park (03/06/2015).

- EMFSL hosted a visit by the Technical Adviser for Japan Association for Techno-innovation of Agriculture, Forestry and Fisheries; Executive Director of Japan Bakery Institute, and Researcher from National Food Research Institute Tsukuba (03/10/2015).
- EMFSL was included on agenda for three PCAST staff visiting multiple labs at ARS Beltsville (08/26/2015).
- EMFSL was included on the agenda for Dr. Deirdra Chester and Dr. Jodi Williams, NIFA national program leaders for Applied Nutrition Research and for Food Safety, during their visit to BARC and BHNRC (09/09/2015).

### **Floral and Nursery Plant Research Unit**

- On April 2, 2015, USNA participated in a BARC-hosted field tour of the Lower Chesapeake LTAR that showcased field plots, measurement devices, modeling, and pollution mitigation. Attendees included ARS and non-ARS LTAR scientists, ARS administrators, NRCS policy makers, and producers
- The USNA hosted a booth at MANTS January 14-16, 2015, where we highlighted the impact of our research and collections on the nursery industry. The show was attended by over 11,000 paid registrants from 44 states and 13 countries representing green industry professionals.

### **Invasive Insect Biocontrol and Behavior Laboratory**

- Hosted participants in the Brown Marmorated Stink Bug (BMSB) Working Group meeting, for tour of laboratory and field research related to BMSB biological and behavioral control of this invasive pest and related stink bugs and squash bugs (6/11/2015)

### **Genetic Improvement of Fruits and Vegetables Laboratory**

- Chaired the 2015 International meeting of the North American Strawberry Growers Association and the North American Strawberry Symposium, a unique meeting bringing together scientists, growers, and industry members. ARS support for these events builds trust and facilitates communication as well as two-way support between ARS and industry from around the world. (February 3-6, 2015, Ventura, CA)

### **Soybean Genomics and Improvement Laboratory**

- Hosted a visit by women agricultural scientists from Pakistan sponsored by the U.S. Department of State, Bureau of Educational and Cultural Affairs, as part of a three-week study project titled “Women in Agriculture: Developing the Next Generation of Leaders.” (12/8/15)
- Hosted a meeting and led a tour of the Electron and Confocal Microscopy Unit for the President’s Council of Advisors for Science and Technology (8/26/15)
- Led a tour of the Electron and Confocal Microscopy Unit for young girls sponsored by the White House Council of Women and Girls Champions of Change (9/15/15)
- A joint Symposium with UMD was held at the Ag Library. The symposium was directed to Organic Production; Food, health and Ecosystems; held Nov 13, 2014

## **Michigan:**

### **Sugarbeet and Bean Research Unit**

- Presented field research progress to over 150 growers and industry personnel at the Saginaw Valley Research and Extension Center’s field day in Richville, Michigan. Disease nursery operations as well as examples of dry bean and sugar beet germplasm in the germplasm enhancement and genetic analysis pipelines were presented. 8/26/15
- Gave a presentation on the latest research progress on spectral imaging technology for quality inspection of pickling vegetables to about 50 pickling growers and processors at the Midwest Pickle Association’s annual meeting in Grand Rapids, Michigan. 12/9/14

## **Minnesota:**

### **Cereal Disease Laboratory Research Unit**

- Provided Ug99 race group molecular diagnostic and genotyping services for over 500 samples from 10 countries: Azerbaijan, Eritrea, Ethiopia, Iran, Iraq, Kenya, Lebanon, Nepal, Tanzania, and Uganda. 2015

- Coordinated the launch meeting of the rust component of the USAID funded project “Seed multiplication and delivery of high-yielding rust resistant bread and durum wheat varieties to Ethiopian farmers” at St. Paul, MN. 2/18-24/15
- Evaluated entries from the eastern (31 lines) and southern (30) soft red winter wheat nurseries, southern (42) and northern hard red (41) winter wheat nurseries, and hard red spring wheat (33) nursery; Gulf Atlantic (44) SUNWHT test (79) and Mason-Dixon (79) nurseries for leaf rust resistance in seedling tests. Seedling genes were postulated in breeding lines based on leaf rust infection types. Data was communicated directly to nursery organizers and wheat breeders. 2015
- Present the seminar “Contribution of environment and pathogen race to effectiveness of adult plant resistance to wheat stem rust” at the Borlaug Global Rust Initiative (BGRI) Technical Workshop, Sydney, Australia. Coordinated and led a satellite meeting at the BGRI Technical Workshop with collaborators of the “Seed multiplication and delivery of high-yielding rust resistant bread and durum wheat varieties to Ethiopian farmers” USAID project. 9/20/15

### **Plant Science Research Unit**

- Presentations were made at the Idaho Hay and Forage Conference in Burley, Idaho to approximately 200 producers and industry representatives on strategies to reduce the impact of foliar and root diseases on alfalfa production (2/27/2015).
- Presentations were made at the Industry Extension Forage Advisory Council in LaCrosse, WI to alfalfa and forage seed industry and extension educators on new races of alfalfa pathogens identified in the Midwest and strategies to reduce damage from the diseases. 3/13/15

### **Soil and Water Management Research**

- Participated in the North Central Extension Research Activity (NCERA-217) annual meeting describing the concept of landscape storage of water for reuse in irrigation and by providing training on alternative tile drainage inlet designs to ≈65 resource, regulatory, university, and industry personnel from multiple states (4/14/2015).

### **Soil Management Research Unit**

- Demonstrated nutritional value and ecosystem services of hulled wheats to university students and farmers at the Agro-ecology Summit near Windom, Minnesota. Provided practical information and guidelines on their inclusion in current and future crop rotations and their potential environmental benefits as efficient nutrient users and recyclers. 8/14/15
- Organized the annual field day at the North Central Soil Conservation Research Lab for the local farming community. Solicited contributions for presentations and demonstrations on new management practices and the use of airborne digital imagery in agricultural research and practical field monitoring and data collection (~80 farmers/attendees). The Morris Sun and Tribune published an article in the August 1 issue covering the event: <http://www.morrissuntribune.com/news/3808728-healthy-soils-healthy-world-ars-scientists-share-research-field-day> 7/23/15
- Co-hosted 10 students from Australian universities with the University of Minnesota-Morris in Morris, Minnesota. This tour and information exchange was part of the GO Minnesota: Innovations in Environmental Sustainability 2015, which is a summer sustainability program for international students. 7/16/15
- Hosted three farmers and three renewable energy/ag researchers from Sweden at the North Central Soil Conservation Research Laboratory in Morris, Minnesota. The international visitors were interested in reducing fossil energy use in agriculture and improving both carbon and environmental footprints of their agricultural systems. 3/18/15

### **Mississippi:**

#### **Cotton Ginning Research Unit**

- Cotton Ginning Research Unit and the Office of Technology Transfer hosted the Stoneville Ginners School sponsored by the National Cotton Ginners Association. Over 20 instructors from industry, other ARS locations, and universities are expecting to teach over 100 students from across the cotton growing belt about the proper operation and management of cotton ginning. (6/9-11/2015) hosted a visit and tour for the U.S. Army Corps of Engineers Research and Development Center, Vicksburg, MS to discuss possible collaborative research on biological control

of aquatic weeds. (3/13/2014)

- Cotton Ginning Research Unit, co-hosted a meeting with Delta Council for the Southern Cotton Ginners Association, speaking to producers and ginners on the latest research in cotton ginning. (7/23/2015)

### **Crop Genetics Research Unit**

- Crop Genetics Research Unit, hosted the Southern Soybean Breeders Tour 2015. This is an opportunity for private and public soybean breeders to view the Uniform Soybean Tests –Southern States trials located at Stoneville. It was attended by 82 visitors, including 2 scientists from Uruguay and two from Paraguay. (8/26-27/2015)

### **National Sedimentation Unit**

- National Sedimentation Laboratory, hosted guests from Bosnia Hercegovina as part of the Cochran Fellows Program. (8/7/2015)

### **Thad Cochran Southern Horticultural Laboratory**

- ARS Thad Cochran Southern Horticultural Laboratory in Poplarville, MS, and Mississippi State University co-hosted Muscadine Field Day. The annual event showcases the muscadine grape, a native U.S. grape with economic potential for small farmers. More than 130 people attended the event (8/29/2015)
- Thad Cochran Southern Horticultural Laboratory, hosted Poplarville's Annual Blueberry Jubilee. Approximately 300 people tour the research facilities during the Blueberry Jubilee. (6/13/2015)
- Thad Cochran Southern Horticultural Laboratory, co-hosted with Mississippi State University Cooperative Extension Service an inaugural honey bee pest management workshop. Over 100 local beekeepers attended and learned about current control strategies for Varroa mites and small-hive beetles. (9/26/2015).
- Hosted a research exchange meeting with numerous University colleagues on determining the impact of southern row crop pesticides on honey bee health. Over 30 attendees with discuss on-going projects as well as plans for future work. (3/10-11/2015)

### **Watershed Physical Processes Research Unit**

- Watershed Physical Processes Research Unit, hosted the S1048 Regional Project Meeting at the National Sedimentation Laboratory in Oxford, Mississippi. The project focuses on the "Assessment of the Carbon Sequestration Potential of Common Agricultural Systems on Benchmark Soils across the Southern Region Climate Gradient. (4/28-29/2015)
- Watershed Physical Processes Research Unit, hosted RUSLE2 training sessions and work with collaborators at Pontificia Universidad Catolica de Valparaiso to adapt the RUSLE2 computer model to work with Chilean conditions at Vina del Mar, Chile. (5/10-17/2015)

### **Missouri:**

#### **Cropping Systems and Water Quality Research Unit**

- Presentation to the Missouri Department of Natural Resources (MDNR) on the APEX and modeling expertise available at the University and within ARS, and to the Soil and Water Conservation Commission. 2/11/15.
- Presented "Cover Crop Effects on Nutrient Cycling and Fertilizer Recommendations" 44th NC Extension-Industry Soil Fertility Conference. Des Moines, IA. 11/19/15.
- Presented "Technology Trends in Precision Agriculture" at the Red River Valley Research Corridor Precision Ag Summit, in Jamestown, ND. 1/19/15
- Presented at the Soil Biology and Soil Health in Hundley-Whaley Research Center Field Day and Missouri Soil Health Exposition in Albany, MO.
- Soil Health and the Role of Soil Biology. USDA Cochran Fellowship Program: High-Value Horticultural Production/CAFNR International Program (15 fellows from Turjikistan and Turkmenisan). Columbia, MO.
- Presented "Cover Crops and Nitrogen Credits." MU Crop Injury Clinic. Columbia, MO. 7/29/15.

Montana:

**Fort Keogh Livestock & Range Research Laboratory**

- Southeastern Montana Livestock Association's semiannual meeting was attended by ranchers and industry leaders. Discussion surrounding evaluation management schemes to promote cow lifetime productivity.
- Montana Stock Grower Association meeting was attended by over 180 industry leaders, ranchers and agency personnel. Discussions on research productivity and future planning.
- Scientists and technicians from Fort Keogh met with scientists from all over the continent and shared research perspectives and findings. Audience consisted of researchers, agency employees, and graduate students

**Northern Plains Agricultural Research Laboratory**

- Discussions of the ARS Fall Focus Group included research on cover crops and economic impacts associated with cover crops.
- The National Grasshopper Board meeting included ARS and University researchers, state entomologists, state plant health directors and plant regulatory officials. Scientists shared research results on microbial control and grazing and fire management of grasshoppers and Mormon crickets.
- Scientists participated in weed management training for private pesticide applicators. The event was part of the Glendive AgriTrade Exhibition. The training provides researchers, ranchers and farmers with the latest information on weeds and pesticide research for safely managing weeds and insect pests.
- ARS research scientists were invited to speak at the Montana Farm Bureau Conference. The statewide conference had approximately 200 Bureau members, farmers, ranchers and researchers in attendance. Presentations on microbial products to replace environmentally-unfriendly chemicals, future of biological alternatives, new bio-based jet fuel, and Jet fuel from oilseeds were given.
- ARS Field Day "Drone 101 Workshop" and Research Talks featured two local flyers, one long-time hobbyist and a recent recipient of a federal Aviation Administration exemption allowing him to fly commercially, acquainted tour goers with basics of their quadcopter and fixed wing machines including flight demonstrations and discussion. Presentations on wheat stem saw-fly, Canada thistle biocontrol research, and nitrogen rate impacts on greenhouse gas emissions under wheat-pea rotations.

Nebraska:

**U.S. Meat Animal Research Center**

- As part of the Nebraska Sheep & Goat Producers Association Annual Meeting and Conference, producers visited USMARC to hear about research related to Ovine Progressive pneumonia and sheep production systems. The event concluded with a tour of USMARC.
- As part of the annual conference for the National Swine Improvement Federation Symposium, USMARC hosted more than 80 swine producers, researchers and industry leaders. Topics included an overview of swine genomics, assessment of functional genetic variants, swine nutrition, gilt development, sow metabolomics, and swine fetal development.
- USMARC hosted a pre-conference tour for the 68th Annual American Meat Science Association Reciprocal Meat Conference attendees. USMARC showcased research findings and facilities to current and future leaders in the meat science community. Impacts from this event include future collaborations with university faculty and meat science professionals.
- Members of the Beef, Sheep, and Swine Focus Group met with ARS Scientists at USMARC to discuss industry research.

**Grain, Forage, and Bioenergy Research Unit**

- Scientists from Lincoln led the Vermeer-Cen USA Bioenergy Field Day in Pella, IA for certified crop advisors, extension agents and farmers. Discussions were held on the use of native perennial grasses for biomass production and potential bioenergy markets.
- The Hard Winter Wheat Breeders Field Day was organized by scientists from both Lincoln and Manhattan. Discussions of wheat breeding trials, disease resistance, and quality attributes of advanced wheat breeding lines from both public and private programs were held.

- The Winter Wheat Field Day was held at the University of Nebraska. Over sixty wheat growers and scientists attended the event. Wheat producers were able to view new wheat cultivars that might be adapted to their production environments and evaluate their disease responses.

### New Mexico:

#### **Range Management Unit Jornada Experimental Range**

- The Range Management Unit hosted a field day for K-12 students to expose them to agriculture, ecology, botany, and zoology. Over two-thousand students were involved.

### New York:

#### **Grape Genetics Research Unit**

- Gave two tours of the grape germplasm to the Fingerlakes Community College "Introduction to Viticulture and Enology" classes. Around 30 undergraduate students in total (9/14 and 9/17, 2015, Geneva, NY).

#### **Plant Genetic Resources Unit**

- Apple collection tour to Professor Tom Drennen, Chair Economics and Environmental Studies classes, Hobart and William Smith Colleges with 57 students, 4 TAs, and 4 professors (9/30/2015, Geneva, NY) Gave two tours of the grape germplasm to the Fingerlakes Community College "Introduction to Viticulture and Enology" classes. Around 30 undergraduate students in total (9/14 and 9/17, 2015, Geneva, NY).
- Hosted Cornell University course PLBR 4060 - Methods of Plant Breeding Laboratory. Helped teach students and scholars about Malus collection (9/19/2015, Geneva, NY)
- Tour of the Malus collection to 20 students, TAs, and Professor Melissa Luckow "Plants and People" class (9/22/2015, Geneva, NY)
- Tour of the Malus collection to 21 apple growers, researchers, and extension agents from China and Cornell University (9/22/2015, Geneva, NY)
- Malus collection open house with 6 stakeholders (9/23/2015, Geneva, NY)
- Apple collection to Professor Elizabeth Newell "Organisms and Populations" class with 20+ students and 3 professors (9/25/2015, Geneva, NY)
- Northern Organic Vegetable Improvement Collaborative (NOVIC) outreach to Northeast Organic Farming Association (NOFA)-NY 33rd Annual Winter Conference. This conference was attended by ~1,100 growers, educators, students, researchers and entrepreneurs. We provided educational material on seed saving and promoted NOVIC's activities to develop new varieties of vegetables that are adapted to organic conditions in northern climates (1/23 - 1/25/2015, Saratoga Springs, NY).
- Northern Organic Vegetable Improvement Collaborative (NOVIC) outreach to Maine Organic Farmers and Gardeners Association (MOFGA) at the 38th Annual Common Ground Country Fair. The fair was attended by over 50,000 people and emphasized workshops and conferences about farming, gardening and environmentally conscious practices. We provided free vegetable seed samples, educational material on seed saving, demonstrations of seed processing, hands-on seed cleaning, and promoted NOVIC's activities to develop new varieties of vegetables that are adapted to organic conditions in northern climates (9/25 - 9/27/2015, Unity, Maine).
- Gave tour to the Malus collection to Professor Maryann Herman class with 8 students (4/7/2015, Geneva, NY)
- Tour of the Malus collection to 9 cider grower and makers (5/8/2015, Geneva, NY)
- Tour of the Apple collection and discussion (8/9/2015, Geneva, NY)
- Tour of the Vitis collection to 50 participants of the North American Grape Breeder meeting (8/27/2015, Geneva, NY)
- Tour of the Apple collection and discussion (10/10/2015, Geneva, NY)
- Tour of the Apple collection to 57 participants of the Great Lake Fruit Growers Meeting (11/10/2015, Geneva, NY)

#### **USDA-ARS Robert W. Holley Center for Agriculture and Health**

- Provided training in various aspects of insect pathology and microbial biocontrol and collaborated on research aimed

at biological control of thrips and wood-boring beetles

- Taught basic biology, ecology, and taxonomy of insects to grade school- and high school-aged students. Instructed students in techniques for collection and preservation of insects and directed exhibition of student insect collections at County and State Fairs
- On August 11, 12, and 13th, 2015, employees at the ARS Robert W. Holley Center in Ithaca, NY participated in the Empire Farm Days event held in Seneca Falls, NY as part of an outreach activity. ARS scientists displayed and explained the research that is performed at the Robert W. Holley Center and provided informational handouts to help the public learn more about agricultural research at the USDA-ARS.
- On February 26, 27, and 28th, 2015, employees at the ARS Robert W. Holley Center in Ithaca, NY participated in the New York State Farm Show held in Syracuse, NY as part of an outreach activity. The annual NYS Farm Show is one of the largest agriculture shows in the Northeast, attracting over 25,000 people and 400 vendors. ARS scientists explained their research projects and provided informational handouts regarding agricultural research at the USDA-ARS to the public.

### North Dakota:

#### **Northern Great Plains Research Laboratory**

- The Northern Great Plains Research Laboratory scientists partnered with NRCS, the Area 4 Soil Conservation District Research Farm, North Dakota State University, and Bismarck State College to host an expanded program, "Farming for the Bottom Line." The day-long program featured USDA and non-Agency experts focused on assisting family farmers reduce costs and optimize yields with reduced long-term environmental impact, and improve marketing expertise. More than 250 farmers and students attended the program held at the Bismarck State College National Energy Center Auditorium.
- The Northern Great Plains Research Laboratory in Mandan, ND welcomed the public to their 17th annual Friends & Neighbors Day. The afternoon event featured presentations, exhibits, and demonstrations by the ARS scientific and technical staff, exhibits of antique and modern farm equipment, children's educational activities, an all-afternoon barbecue, and tours of ARS research. There were also exhibits and presentations by NRCS, FSA, APHIS, Forest Service, Rural Development, and numerous non-USDA agencies and organizations. More than 750 people from family farms, ranches, and the community attended this annual civic event.

#### **Sunflower and Plant Biology Research Unit)**

- This forum made of USDA-ARS personnel and their North Dakota State University partners presented talks and posters to about 70 stakeholders, farmers, and university personnel. This annual forum transfers technology between scientists, stakeholders, partners, and farmers to improve the production of sunflower in the U.S.

#### **The Red River Agricultural Research Center**

- The Red River Agricultural Research Center (RRVARC) Research Partners' Annual Meeting with representatives from all of the major agriculture sectors in ND and the upper mid-West States. Presentations were given by commodity/industry representatives on research needs and included, Mike Davis, President - American Malting Barley Assoc.; Barry Coleman, Executive Director - Northern Canola Growers Association; Steve Edwardson, Executive Director - ND Barley Council; Neal Fisher, Administrator - North Dakota Wheat Commission; Chuck Gunnerson, President - Northern Plains Potato Growers Association; John Sandbakken, Executive Director - National Sunflower Association; Joel Tenney, Executive Vice President, - ICA Trinova, LLC; Mike Metzger, Research Agronomist, Minn-Dak Farmers Cooperative; Stan Wolf, 1st Past President - ND Weed Control Association; Tom Lilja, Executive Vice President, ND Corn Growers Association; and Richard Vierling, Director of Research, National Corn Growers Association. Research Leaders from the five USDA-RRVARC Management Units also provided highlighted accomplishments from each of their respective commodity-specific responsibilities. Commodity and industry representatives expressed sincere appreciation for the many accomplishments of USDA researchers at Fargo & throughout the entire country, and discussed coordinating efforts to sustain USDA research through delegation visits with USDA leadership in Beltsville, MD and with Congress in Washington, DC.

Ohio:

**Application Technology Research Unit**

- Presented a talk on managing the greenhouse environment at Barco Sons, Inc., Medina, OH. (12/5/14)
- Stakeholder Liaison Conference at Toledo Botanical Gardens in Toledo, Ohio regarding current and future research programs involving growing substrates, plant nutrition (including silicon), energy-efficient production methods, container weed control, biochar and steel slag amendments, and Virtual Grower. (3/11/15)
- Virtual Grower 3.1, a decision-support software program, was developed and released. (203 downloads since software was made available 7/10/15)
- Presented intelligent spray technology to improve pesticide application efficiency, reduce pesticide use and safeguard the environment at the 18th World Congress of International Commission of Agricultural and Biosystems Engineering (CIGR) in Beijing, China, (9/16-19/2014)
- Presentation titled "Optimization of pesticide spray application rates to match sprayer and crop parameters" in Columbus, OH 1/7-9/15
- Presented to over 40 greenhouse growers, farm managers, sprayer manufacturer reps, students and researchers. 1/22/15

**Corn, Soybean and Wheat Quality Research Unit**

- Participated at Wheat Growers board meeting, held at Delaware, Ohio, by presenting new data on viruses in Ohio wheat conveying and discussing important next steps to assess their impact on production leading; ongoing project with wheat growers. Meeting attended by approximately 15 Ohio wheat growers. 9/14
- Provided training workshop on Methods for diagnosis of Maize Lethal Necrosis causing viruses in seed during visit to Rwanda Agriculture Board Seed Laboratory. Attended by 4 Rwanda Agriculture Board and One Acre Fund researchers. 7/26/14 to 8/5/2014
- Participated in surveying maize crops for virus disease in all maize growing areas of Rwanda. Taught techniques for collecting, storing and stabilizing plant samples for virus diagnosis and the use of tissue blot immunoassays for virus diagnosis in maize to 20 researchers at the Rwanda Agricultural Board. 1/26-30/15
- Participated in the Ohio Wheat Workshop in Plain City, Ohio), and discussed efforts to overcome the quality and yield challenges in Ohio wheat production. Developed an action plan for increased wheat production and quality in Ohio. Attended by over 40 wheat growers, breeders, grower organizations and traders. 6/11/15
- Gave presentation on Flour yield traits and extended uses of eastern soft wheat at the American Bakers' Association Meeting in Columbus, Ohio. 11/6/14

**Soil Drainage Research Unit**

- Presented a webinar on application of ground penetrating radar for agriculture. Attended by 50 local, state, and federal agency staff; industry personnel, and university researchers. A recording of the webinar is maintained and remains available at: [www.ag-geophysics.org](http://www.ag-geophysics.org). 9/30/14
- Presented poster titled "Quantifying the impacts of agricultural management on water quality: Edge-of-field monitoring and modeling" at SERA-46/Hypoxia Task Force Meeting, held in Columbus, Ohio. Attended by approximately 100 state and federal agencies, non-government organizations, watershed stakeholders, and policy makers. 5/19/15
- Presented an illustrated lecture titled "Agricultural Drainage - Pros and Cons", at a Western Lake Erie Basin Drainage Conference held in Maumee Bay State Park, Oregon, OH, arranged by The Nature Conservancy. Attended by approximately 75 local elected officials, especially County Engineers and Drainage Commissioners. 8/20/15
- Presented "Influence of grass filter strips on the structure and function of agricultural headwater streams in central Ohio" at the Deeply Rooted in Restoration, the 2014 Natural Areas Conference, held in Dayton, Ohio. Attended by 60 watershed managers, Natural Resource Conservation Service personnel, state natural resources staff, university faculty and students, non-profit organizations involved with management of natural areas, and consultants. (10/16/14)
- Presented "Influence of grass filter strips on the structure and function of agricultural headwater streams in central Ohio" at the Deeply Rooted in Restoration, the 2014 Natural Areas Conference, held in Dayton, Ohio. Attended by 60 watershed managers, Natural Resource Conservation Service personnel, state natural resources staff, university faculty and students, non-profit organizations involved with management of natural areas, and consultants.

(10/16/14)

Oregon:

**Eastern Oregon Agricultural Research Unit**

- Organized a cooperative program between ARS scientists and OSU extension agents to develop land management plans and address issues in sagebrush steppe animal and plant populations with college and high school student groups. (11/12/14)
- Updated group of 30 Natural Resource Conservation Service managers on recent findings for managing medusahead in sagebrush rangelands. (10/28/14)
- Provided scientific basis for managing sage-grouse populations and the State and Transition Models for Sagebrush Steppe approved for the Candidate Conservation Agreement with Assurances adopted by the US Fish and Wildlife Service. (12/15/14)
- Provided 80+ western rangeland management professionals and stakeholders with research findings for managing annual grass infested rangelands threatening large tracts of sage-grouse habitat in the west. (1/13/15)
- Provided scientific background and research findings to Oregon Sage-Con Habitat Quantification Committee for greater sage-grouse. Their research is the basis for developing a quantification tool for Oregon guidelines. (1/16/15)
- Showcased scientists' research and provided numerous copies of ARS Manager Decision Guidelines (print and video) to 800 + rangeland science professionals and university students. (2/2-4/15)
- Provided research on rangeland weed management and restoration for 20+ ranchers, agency personnel, non- profit organizations and members of advisory council. (2/19/15)

**Range and Meadow Forage Management Research Unit**

- University students participated in activities and learning events on the rangeland with the goal of gaining field experience in rangeland ecosystems. Scientists instructed on systems approach to Sage-grouse management including state and transition habitat model, Ecologically-based invasive plant management (EBIPM), Seed technology to enhance restoration, and Western Juniper management and fire ecology. Students teamed in a rangeland management competition for improving sage-grouse habitat. Shasta College advisor said, the “event may have been the MOST worthwhile hands-on workshop I have attended.” (4/23-26/15)
- ARS scientists and technicians hosted over 60 elementary school students from Harney County, Oregon including students from the county’s rural one room schools to learn about basic plant physiology and plants in the ecosystem. This annual field trip was the subject of an ARS award winning video several years ago - “Making the Science Connection”, a step by step guide for ARS stations and scientists hosting educational field trips. (5/7/15)
- Presented research on sage-grouse habitat management adopted by land managers on over 1.2 million acres of sagebrush rangeland. Students from Evergreen State College and University of Idaho were provided with on overview of rangeland management research. (5/14,20/15)
- Presented systems approach to Sage-grouse management including State and Transition Habitat Model Western Juniper management and fire ecology, and ecologically-based invasive plant management (EBIPM)s event to members of the board of The Nature Conservancy, and college students completing a rangeland management plan as part of a course in collaborative design. (6/5,11/15)
- ARS scientists and technicians presented information and led field tours on interactions between fire and grazing and juniper encroachment, collaborative partnerships in resource management, seed technology in rangeland restoration techniques, and interactions between annual grasses and fire in sage-grouse habitat. Field Days were organized for Pacific Northwest Section Society for Range Management professionals that will implement research findings in sagebrush steppe rangeland management, and the International Rangeland Seminar for the US Forest Service. (6/15-16/15, 8/7/15)
- Conducted a 4 day camp for high school students interested in exploring the rangeland science field and career opportunities available with college degrees. This was the 5th annual range camp conducted by Burns USDA-ARS and it has proven to be a very valuable outreach program. The top camper attends the High School Youth Forum at the annual conference of the Society for Range Management. (6/17-20/15)
- Provided the scientific information on Juniper management and fire ecology, and fuels management with annual grasses for decision making on rangeland fire policy and resources in eastern Oregon. Participants included agency personnel with fire responsibilities, private land owners and environmental groups. (8/26/15)

### Horticultural Crops Research Unit

- Presented research on the cold hardiness of lesser-known wine grape cultivars at the BC Wine Grape Council Annual Enology & Viticulture Conference and Tradeshow in Penticton, British Columbia, Canada. Approximately 300 growers, winemakers and related industry personnel attended the two day conference (07/20/15).
- Presented at the Northwest's premier wine community trade show and educational event on their current winegrape research and overview of wine style metabolites. Approximately 300 growers, winemakers, and additional private company personnel attended this session on farming for wine styles (02/25/15).
- Had a demonstration booth where individuals could run a LAMP assay (nucleic acid amplification technique) to quantify the amount of *Erysiphe necator* inoculum present in air samples. The detection technique is used to adjust the timing of fungicides applications for the management of grape powdery mildew. (2/24/15)
- Presented information on Grapevine Red Blotch Virus and other important viruses of grapevine that occur in Oregon. Participants included 120 growers, and 40 board meeting attendees who will use the information to develop an RFA. (7/28/15, 8/12,20,25/15)
- Delivered several workshop modules managing nutrition and viruses, and bacterial and fungal diseases of grapes as part of the Oregon Wine Research Institute's vineyard management workshop in Grants Pass, OR. (7/28/15)
- Co-presented with an OSU colleague an overview of water use and how to monitor water stress in grapevines in dry-farmed vineyards, to approximately 120 growers and viticulture professionals.
- Presented a summary of recent findings regarding Nitrogen, Phosphorus, and Potassium thresholds for Pinot noir nutrient status, and practical methods to track and manage grapevine nutrition. (3/10/15)
- Described ongoing research on Blueberry Fruit Drop Virus, Blueberry Scorch Virus and Blueberry Shock Virus and Raspberry Bushy Dwarf Virus to growers and consultants in Lynden, WA. (8/13/15)
- Provided update on progress of berry breeding program in the Pacific Northwest, and shared information on new selection development, naming, grower trials, and discarded selections. Presentations were made to Washington State University, AgCanada, Washington Red Raspberry Commission, Washington Blueberry Commission, and commercial nurseries. (10/21-22, 11/18/2014)
- Provided tours of the breeding plots and discussed performance of various selections and cultivars to determine which varieties were best suited for particular farm conditions. Information was provided to commercial berry growers and nurserymen at numerous events throughout the year and to interested public in conjunction with Blueberry/Caneberry Field Day, International Trials Conference, Oregon Blueberry School, Oregon State University Strawberry Field Day. (3/16-17, 5/19-20, 6/2,9,10,16,23,30, 7/1,7,8,14,21, 8/10,11,31/15)
- Presented Information about cultivars developed and grown in the Pacific Northwest. Discussion included the blooming tendency of strawberry species, and the future of raspberry and blackberry breeding with an emphasis on what traits were going to be given priority. Numerous commercial growers, nurserymen and private company personnel were the recipients of this information. (1/29/15, 2/17/15, 2/26-27/15, 8/26/15)
- Presented samples of new USDA cultivars or selections prepared as individually quick frozen fruit by OSU Department of Food Science to help a Japanese ice cream company and their major Oregon supplier determine whether these new genotypes would work in their product formulation. (4/20/15)
- Convened the NCC 212 Small Fruit Research Meeting. Scientists from industry, universities, and the USDA gathered in Corvallis to discuss research results and progress. (10/28/14)
- Presented information on breeding for resistance to Blueberry shock virus to 30 researchers, commissioners, and representative of the commercial blueberry industry.
- Presented information about day-neutral strawberry selections and cultivars at the Oregon Strawberry Commission Plasticulture Workshop and Demonstration in Forest Grove, OR, and served as information source during on-farm demonstrations in Hillsboro, OR. (8/18/15)
- Scientists displayed thawed, frozen samples of advanced selections and new releases of blueberry, strawberry, red raspberry, black raspberry, and blackberry so that the industry had the opportunity to evaluate, including tasting, these genotypes. Evaluations were conducted throughout the year at many industry meetings and field days including Oregon Blueberry Conference, and Northwest Food Processors Association Meeting. Several hundred people representing the processed food industry and berry growers participated.(12/15,19/14, 1/16,21/15)

### Forage Seed and Cereal Research Unit

- Presented on the development of new hop varieties; molecular and traditional breeding tools; disease control measures to mitigate damage from hop powdery mildew, including emergent, virulent strains of the pathogen; and technologies associated with IPM. Numerous growers, brewers and private company personnel attended the events. (10/29/14, 1/9, 21, 22/15, 6/18/15).

- Provided information on cover crops and benefits to soil health to industry, growers, and representatives from Oregon State University, USDA, NRCS, and OSU extension. (4/30/15)
- University, USDA, growers, NRCS, and Extension Personnel met to discuss potential novel approaches for slug control using RNAi technology. (5/5/15)
- Presented the benefits of biochar-based amendments and proposed future collaborations to the Southern Umpqua Rural Community Program Meeting and industry stakeholders. (6/16,18/15)

### **National Clonal Germplasm Repository**

- Scientists of the National Clonal Germplasm Repository provided guidance on cranberry germplasm preservation and research to 6 scientists from other government research agencies. (4/28/15)
- Site tours of the National Clonal Germplasm Repository in Corvallis, OR were provided to members of the university community, national and international researchers, and interested public and industry representatives throughout the year. Tour highlights include Humulus (Hop) genetic resources, germplasm preservation, the use of tissue culture techniques, and cryopreservation as a pathogen control measures. (2/24/15, 5/21/15, 7/28/15)

### **Soil and Water Conservation Research Unit**

- Presented a breakout session at the Direct Seed and Oilseed Conference in Kennewick, WA on collecting and deciphering precision crop data to make management decisions. Participants included over 60 growers. (1/20/15)

### **Pennsylvania:**

#### **Bio-based and Other Animal Co-Products Laboratory**

- Hosted ASTM International's D31 Committee meeting on Leather on April 22, 2015. The area of interest of the Committee is to establish the standard methods for the assessment of materials used to produce leather and of the ability of the resultant leather to meet end-use performance requirements. (4/22/2015)
- RS scientists produced samples of biobased detergent (called sophorolipids) by fermentation using renewable agricultural feedstocks; the collaborating laboratory (Marmara University, Turkey) tested ARS materials to inhibit animal hides-degrading bacteria. One manuscript has been prepared for submission to peer-review journal, in which the antimicrobial activity of the materials against hides-degrading bacteria was affirmed.

#### **Eastern Regional Research Center**

- Hosted the annual ALCA Research Liaison Committee (RLC) meeting with stakeholders /participants from DC, Delaware, Maine, Michigan, Minnesota, Ohio, Pennsylvania, Wisconsin, South Dakota and Maryland. The relevance of ERRC research to industry needs was discussed. This meeting provided an opportunity for the stakeholders and customers to maintain an awareness of ongoing hides and leather research, to foster research collaborations, and to assist the USDA and other public research institutions in establishing research priorities. (4/23/2015)
- The Center hosted 125 attendees including the Deputy Undersecretary for Research, Education and Economics, Administrator of ARS, Headquarters' personnel, state and local politicians, major stakeholders, customers, collaborators and worldwide known national and international scientists and local media. Highlights of the research accomplishments of ERRC scientists were presented and a tour of the Center included demonstrations of projects showcasing the state of the art instrumentation and the facility. Providing insight into solutions to some of the agricultural problems facing the U.S. today and tomorrow with fundamental, applied, and developmental research being highlighted.

#### **Molecular Characterization for Foodborne Pathogens**

- Co-hosted with E. coli Reference Center at the Pennsylvania State University an international workshop bringing together researchers from ARS, academia, the Centers for Disease Control and Prevention, the Food and Drug Administration, and E. coli experts from various institutions worldwide working on molecular serotyping of E. coli, methods for characterizing and determining E. coli pathotypes, and whole genome sequencing and bioinformatic analyses for genotyping and outbreak surveillance.

#### **Sustainable Biofuels and Co-Products Laboratory**

- All collaborators and stakeholders on this large BRDI grant were invited to discuss research progress and future direction for the project. The FarmBio3 project will demonstrate whether a fast-pyrolysis method of processing biofuel from common agricultural feedstocks can be employed at an efficient and useful scale in farms and villages—one that will be affordable and easy for growers to use, and provide biorefineries with a steady supply.

### South Carolina:

#### **Coastal Plain Soil, Water and Plant Research Center,**

- ARS Coastal Plains Soil, Water, and Plant Research Center in Florence, SC, participated in Clemson University's Pee Dee Research and Education Center Field Day with research in cotton breeding and soil management. Attendance at this year's event was about 240 people including farmers, industry personnel, and extension specialists. (9/10/2015)

### South Dakota:

#### **North Central Agricultural Research Laboratory**

- The 21st annual field day of the North Central Agricultural Research Laboratory in Brookings, SD was held June 16, 2015. Attendance was recorded at 62 non-NCARL visitors plus about 30 employees. Attendees included agricultural producers, crop consultants, extension professionals, educators, and the general public. The topic was "Measuring Success: Beyond another Bushel" and included presentations and discussion on the value of soil health and increasing soil biology, developing resilient crop production systems, the value of including pollinator-friendly crops, and managing weed resistance. As an outcome of the meeting, agricultural professionals and the general public have an improved understanding of new land management practices, the impact of agricultural management on food production, and the mission of ARS and NCARL.

### Spain:

#### **Animal Genomics and Improvement Laboratory**

- Presented (by invitation) talks on Animal Genomics and Improvement Laboratory research at the ANEMBE (National Association of Bovine Medicine Specialists of Spain) Bovine Medicine International Congress XX in Burgos (5/6-8/2015)

### Tennessee:

#### **Floral and Nursery Plants Research Unit**

- On June 17, 2015, FNPRU staff co-hosted with TSU a field day for industry partners, nursery growers, and the general public. Over 150 attendees participated in workshops and listened to speakers on topics related to pest control, best nursery practices, plant production, and propagation techniques. Follow-up evaluations revealed that 100% of respondents "learned something new" and 95% plan to "adopt or use some of the information" they learned.

### Texas:

#### **Cotton Production and Processing Research Unit**

- The National Cotton Ginners Association's Gin School provided levels I-III and continuing education. The classes on gin and equipment safety, hydraulics, electricity, equipment settings and repair, seed cotton machinery unloading and handling systems. The continuing education focused on OSHA regulations and safety management practices.

#### **Cropping Systems Research Laboratory**

- The 2015 meeting and Field day included a Field tour and research updates with Executive officers of US Sorghum Checkoff Program and National Sorghum Producers (NSP). Promote and strengthen research agreements and cooperation of ARS scientists with the primary commodity organization representing the US sorghum industry.

### **Grazinglands Research Laboratory**

- The Grazinglands Research Laboratory Field Day 2015 on October 15, was attended by about 250 people. About one third of attendees were producers, one third were families (primarily home schooled), and numerous cooperators and community members. Congressman Lucas and several of his staff members and two staff members from Senator Langford's office attended.

### Utah:

#### **Forage and Range Research Laboratory**

- Met with seed company representatives, USU extension and range management professional societies to inform them of newly available seed materials, current research, and identify new target areas. (10/22/14)
- Trade Show booth display of information on genetically improved plant materials releases (grasses, legumes, and forbs). Of the 150 attendees, approximately 20 ranchers and general public picked up samples of grass, legume, and forage kochia seed and received information on establishing grasses, legumes, and shrubs on range and pasturelands. (2/6-7/15)
- Provided information on improved plant materials and enhanced management practices for rangelands, pastures, and turf in the western U.S to approximately 150 producers, federal agents, and private company representatives. (11/6-8, 12/3-5/14)
- Presented information, brochures, and sample seeds of FRRL releases for improvement of irrigated and non-irrigated pastures. There were approximately 350 attendees including ranchers, seed company representatives, Utah Farm Bureau, and NGOs.
- Winter Seed School for western alfalfa seed growers and Inaugural Bee Workshop for beekeepers (1/25-27/15)
- Presented seminar on the rehabilitation of big sagebrush sites in northern Utah at the 2015 Society for Rangeland Management-Northern Utah Chapter Annual Tour in Cedar Fort UT and Birdseye UT. The field day featured information on improving rangeland health through novel management practices and FRRL plant materials. (6/2/15)
- Presented the genetic nature of economically important traits; and demonstrations of novel plant materials with improved yield and quality for pastures, improved stand establishment, and persistence for enhanced rangeland productivity. Discussed new germplasm releases and associated management technologies related to reductions in financial inputs and higher yield and quality. Approximately 30 Western Region Farm Bureau presidents and administrators from CO, WY, UT, NV, and ID were in attendance. (7/28/15)

### Washington:

#### **Animal Diseases Research Unit**

- Featured speaker to American Goat Federation and American Sheep Industry. He provided information on research unit results to these stakeholder groups. (1/28/15)

#### **Grain Legume Genetics and Physiology Research Unit**

- Scientists met at Washington State University with approximately 20 members of a trade delegation from India and representatives for the U.S. edible legume industry. The scientists presented visual samples of elite ARS chickpea breeding lines and new varieties and discussed seed quality traits of special importance to consumers in India. (10/15/14)
- Presented at the Washington State Weed Conference on the biology, identification, and management of nightshade species in crop rotations. Approximately 50 growers and private company personnel attended. (11/6/14)
- Presented on rattail fescue and other problem weeds management in mint. Approximately 200 growers, researchers, and private company personnel attended the events. (12/2/14, 1/20/15)
- Presented at the Annual Meeting of the Western Pea and Lentil Growers Association. Topics presented include updates on grain legume breeding, endemic and emerging diseases of grain legumes, and strategies for controlling weeds. Approximately 200 growers and industry personnel were in attendance. (12/2/15)
- Scientists presented on research to manage grass weeds in grass seed production. Approximately 50 producers, researchers, and seed company personnel attended. (12/10/14)
- Hosted field managers, seed treatment technicians, and business managers of Pacific Northwest Growers Cooperative. Results of 2014 yield trials were presented to the audience and they had the chance to look at seed samples of elite varieties of pea, lentil, and chickpea developed by the research unit. (12/19/15)

- Presented on cool season food legume breeding efforts; advances in pea, lentil, and chickpea variety development; and on the recent discovery of an emerging disease of chickpea. Events include the annual research review of the USA Dry Pea and Lentil Council Research, annual meeting of Blue Mountain Seed Co., USA Dry Pea and Lentil Council Variety Release Committee. The meetings were attended by numerous industry personnel, and university and federal scientists. (2/5,19/15, 3/12/15)
- Presented at the Washington State Mint Convention, Pasco, WA on status and management of herbicide resistant weeds in processed vegetable production areas of Washington State. Approximately 100 producers, researchers, and crop consultants attended. (12/11-12/14)
- Presented a research summary at the Washington Hop Commission and Hop Research Council grower meeting in Yakima, WA on weed management in hops and efficacy of hop bine desiccants. Approximately 120 growers, buyers, researchers, and crop consultants attended. (8/5/15)

### **Northwest Sustainable Agroecosystems**

- Presented information on weed-suppressive bacteria, registration by EPA, and NEPA information available to hasten the use of these bioherbicides on federal lands. Communication to over 200 producers, growers, ranchers, and land managers from state and county agencies, and federal organizations.(1/7/15, 1/11/15, 1/22/15)
- Presented a seminar on weed-suppressive bacteria applied in winter wheat rotation. Washington Grain Alliance /Commission leaders, administrator, Washington growers, WSU scientists (100 participants) were involved. (2/19/15)
- Discussed establishing grower test plots for cover crops in the low rainfall region and methods of data collection. (2/14/15)
- Reviewed winter canola fertility requirements for the spring with a growers group. (2/24/15)
- Presented two training seminars on 1) soil science and 2) weed-suppressive bacteria. Discussed soil factors involved in vegetation establishment in rangeland to reduce soil and organic matter loss and application of weed-suppressive bacteria as a means to reduce annual grass weeds. Met with land managers to discuss restoration plans that include bacteria; to compile a list of field restorations efforts to test the weed-suppressive bacteria; and to develop interagency collaborations. Information presented to Land Managers from BLM, FWS, NPS, and USFWS at various events. (2/24/15, 3/4/15, 3/11-12/15, 3/24/15)
- Presented on the proper techniques to use microbial products in production systems to improve soil quality and net farm profit. Approximately 14 producers, scientists, land manager, and land owners attended. (10/1-2/15)
- Organized and presented research on winter canola varieties, fertility, and rooting patterns at annual Field Day. Growers, crop consultants, ag chemical dealers, scientists, and extension educators attended. (6/4/15)
- Provided information on the influence of tall standing stripper header stubble on soil moisture and temperature and wind velocity to 50 attendees including growers, conservation district representatives, equipment dealers, and scientists. (6/23/15)
- Presented information on nitrogen loss from farmland by wind erosion to concerned growers at a Field Day in Lind, WA. (6/11/15)

### **Wheat Health, Genetics, and Quality Research Unit**

- Provided laboratory tour, discussed lab operations, wheat quality research, genetic potential of varieties grown in this area, and new varieties with Washington Grain Alliance, Washington State University, Korean Trade Team, and various Japanese companies. (10/3/14, 10/27/14, 5/5/15, 6/29/15, 7/7/15, 7/27/15)

### **Vegetable and Forage Crop Production Research Unit**

- Presented at the McGregor Grower Meeting in Quincy, WA on the incidence and management of herbicide resistant weeds in vegetable cropping systems. Approximately 175 growers, private company personnel, crop consultants, and researchers attended. (2/11/14)

### **Fruit and Vegetable Research Unit**

- Provided information in oral presentations and posters on research results on chemical lures for detection of spotted wing Drosophila and management of cherry fruit fly. The audience of 100 was primarily cherry growers and packers, as well as other researchers. (11/13/14)
- Scientists provided information on the biology, ecology, and management of potato psyllid as a vector of the pathogen causing zebra chip disease of potato. Audiences were comprised of approximately 150 growers and

- commercial pest managers, and 1800 grower and industry representatives. (11/13/14, 1/8/15, 1/29/15)
- Presented research results describing the phytonutrient content of advanced breeding lines from the TriState breeding program to growers and industry at the annual Oregon/Washington Potato Conference. (1/27/15)
- Methods and technologies for attracting and trapping insect pests were presented to approximately 200 grape growers and representatives of the wine industry at the Wine Grape Growers Annual Conference. (02/13/15)
- Presented research findings on pear psyllid endosymbionts, insecticide resistance, and mating disruption. Approximately 100 growers and industry representatives from Washington, Oregon, and California were present. (2/18/15)
- Presented research on phytonutrient content of baby potatoes and potato cyst nematode to over 100 growers and industry members at the Idaho Potato Conference. (1/22/15)
- Presented the biology, pest status, and management of stinging wasps to a group of approximately 100 personnel responsible for property management and pest control in Jacksonville, FL. (3/26/15)
- Presented the risk of zebra chip disease pathogen spreading through export potatoes. POTATO EXPO is the largest conference and trade show for the potato industry held in North America every year. Approximately 1800 potato producers, processors, researchers, and key industry stakeholders attended. (01/8/15)

### **Physiology and Pathology of Tree Fruits Research Unit**

- Presented on apple fruit postharvest biology and technologies to manage fruit ripening and minimize fruit physiological disorders during storage to approximately 100 university chemistry instructors. (10/10/14)
- Presented at the Washington Tree Fruit Research Commission Apple Crop Production Research Review, the Pace International Postharvest Academy, and the AgroFresh Inc. Crunch Clinic on postharvest management of apple fruit to prevent physiological disorders and extend market quality life. Attendees included over 250 growers, researchers, extension, and private company personnel. (1/28/15, 3/25/15, 5/6/15)
- Presented on the management of orchard soil microbiology resources as a means to manage diseases and to limit re-infestation of soils by plant pathogens and parasites. Research, extension, and private company personnel attended the presentations. (12/3/14)
- Presented research on elucidation of apple rootstock genes and metabolism related to disease resistance to an audience of growers, research, extension and private company personnel. (1/30/15)
- Presented on the development of non-fumigant alternatives for the management of soil-borne diseases in strawberry and tree fruit production systems. Approximately 300 growers and private company personnel attended. (2/4/15)
- Delivered presentations summarizing field trials on the use of Brassica seed meal amendments and anaerobic soil disinfestation as alternatives to soil fumigation for the control of strawberry soil-borne diseases. Growers and industry representatives were in attendance. (8/12/15)

### **West Virginia:**

#### **Appalachian Fruit Research Station**

- Open House presented research results and projects related to tree fruit and small fruit production to the general public October 8-9.
- Participated in the 6th Jefferson county Science Olympiad with a presentation on the brown marmorated stinkbug October 19-23

### **Wisconsin:**

#### **Environmentally Integrated Dairy Management Research Unit**

- Low-disturbance manure application methods in a corn silage-rye cover crop system and Winter manure phosphorous loss at the WI Crop Management Conference, Madison, WI. 1/15
- Wisconsin Environmental Health Network Symposium, UW-Madison School of Medicine and Public Health (2/26/15)
- Maintained website for public downloading of APLE P runoff model. Model was downloaded 70 times in FY15. Initiated new website for public downloading of new APLE-Lots barnyard P runoff model. Model was downloaded 4 times in FY15.
- Application of Dairy Slurry on Alfalfa Fields, Midwest Forage Association, Wisconsin Custom Operators, and Professional Nutrient Applicators Association of Wisconsin, Wisconsin Dells, WI (1/21

**U.S. Dairy Forage Research Unit**

- Received official approval from the Association of Official Analytical Chemists International (AOAC) for a starch assay, “AOAC Official Method 2014.10 Dietary Starch in Animal Feeds and Pet Food,” to be used by feed analysis laboratories. It was also posted on the AOAC web site. 4/30/15
- Created and distributed a new computer simulation model, APLE-Lots, to augment the previously created Annual Phosphorus Loss Estimator (APLE) which has gained widespread use among scientists, conservationists, and others working to reduce phosphorus runoff from agricultural systems. While the original model simulates dissolved and sediment-bound phosphorus loss in surface water from cropped fields and pastures, the new APLE-Lots does the same for phosphorus loss from outdoor cattle lots. 5/2015
- Presented talks (“Measures of nitrogen use efficiency and environmental impacts of dairy production systems,” “Effects of manure on legume productivity and persistence,” and “Low-disturbance manure application methods in a corn silage-rye cover crop system”) to 300 crop consultants, animal nutritionists, fertilizer dealers, researchers, Extension educators and producers at the Wisconsin Crop Management Conference. 1/14/15
- Organized and presented research information at a seminar series for about 300 dairy and forage producers and industry representatives at World Dairy Expo. Also created an educational display, “You don’t have to choose between saving the earth and saving money: Economic and environmental sustainability go hand in hand,” for the 77,000 visitors from 44 states and 94 countries who attended the show. 10/4/15
- Gave a presentation, “Best Practices for Using Coproducts in Dairy Diets,” to about 300 ethanol industry personnel, animal nutritionists and researchers at the Distillers Grains Symposium. 5/13/15

**Vegetable Crops Research Unit**

- National Fry Processor Trial Field day in East Grand Forks, MN. 10/1/14
- UW Extension and WPVGA Grower Education Conference in Stevens Point, WI. 2/3-5/15
- California Carrot Symposium in Bakersfield, CA. 3/10/15
- Wisconsin Cranberry School sponsored by the University of Wisconsin-Extension and the Wisconsin State Cranberry Growers Association. Establishing a marker assisted selection (MAS) program for cranberry

### 3.11. Technology Transfer Award Winners

#### FY 2015 ARS Technology Transfer Award

**Scientist:** Dr. Timothy Leeds and Dr. Gregory Wiens

**Lab:** National Center for Cool and Cold Water Aquaculture, Northeast Area, Kearneysville, West Virginia

**Title:** The ARS-Fp-R Team for the development and release of the ARS-Fp-R line of rainbow trout.

#### FY 2015 Federal Laboratories Consortium (FLC) Awards

**Name:** Dr. Sevim Erhan, Eastern Regional Research Center, Wyndmoor, Pennsylvania

**Award:** Laboratory Director of the Year Award

**Lab:** Apple Rootstock Breeding Laboratory

**Title:** New Productive, Disease Resistant Apple Trees

**Award:** National Excellence in Technology Transfer

**Lab:** Coastal Plains Soil, Water and Plant Research Center

**Title:** Quick Wash Process for Removing and Recovering Phosphorus from Wastes

**Award:** National Excellence in Technology Transfer

**Lab:** Environmental Microbial and Food Safety Laboratory

**Title:** Online Imaging for Real-Time Wholesomeness Inspection in Poultry Processing

**Award:** National Excellence in Technology Transfer

**Lab:** Genetic Improvement of Fruits and Vegetables Laboratory

**Name:** 'Flavorfest' Strawberry Cultivar

**Award:** National Excellence in Technology Transfer

**Lab:** National Center for Cool and Cold Water Aquaculture

**Name:** Development and Release of a Disease-Resistant Rainbow Trout Line

**Award:** National Excellence in Technology Transfer

**Lab:** Foodborne Toxin Detection and Prevention Research Unit

**Name:** Improved Detection of Shiga Toxin through Monoclonal Antibodies

**Award:** Far-West Region, Excellence in Technology Transfer

**Lab:** Bioproducts Research Unit

**Name:** Encapsulation of Beneficial Soil Microbes in Starch-Gypsum Matrix for Use in Agriculture

**Award:** Far-West Region, Excellence in Technology Transfer

**Lab:** Soil and Water Management Research Unit

**Name:** Waveguide-On-Access-Tube (WOAT) Time Domain Reflectometry (TDR) System

**Award:** Mid-Continent Region, Excellence in Technology Transfer

**Lab:** Bio-oils Research Unit

**Name:** Commercialization of Estolides as a Biobased Engine Oil

**Award:** Mid-West Region, Excellence in Technology Transfer

**Lab:** Cotton Chemistry and Utilization Research Unit

**Name:** Cotton Nonwoven Fabrics for Disposable Diapers

**Award:** Southeast Region, Excellence in Technology Transfer

**Lab:** Quality & Safety Assessment Research Unit

**Name:** Microwave Moisture Sensor for In-Shell Peanut Kernel Moisture Measurement

**Award:** Southeast Region, Excellence in Technology Transfer

**Lab:** Crop Production Systems Research Unit

**Name:** Herbicide Resistance in Weeds Monitoring and Reporting System

**Award:** Southeast Region, Honorable Mention

**Lab:** Environmental Microbial and Food Safety Laboratory

**Name:** Online Imaging for Real-time Wholesomeness Inspection in Poultry Processing

**Award:** Mid-Atlantic Region, Excellence in Technology Transfer

**Lab:** Genetic Improvement of Fruits and Vegetables Laboratory

**Name:** "Flavorfest" Strawberry Cultivar

**Award:** Mid-Atlantic Region, Excellence in Technology Transfer

**Lab:** Invasive Insects Biocontrol and Behavior Laboratory

**Name:** Reduced Risk Vector Control Insecticides

**Award:** Mid-Atlantic Region, Excellence in Technology Transfer

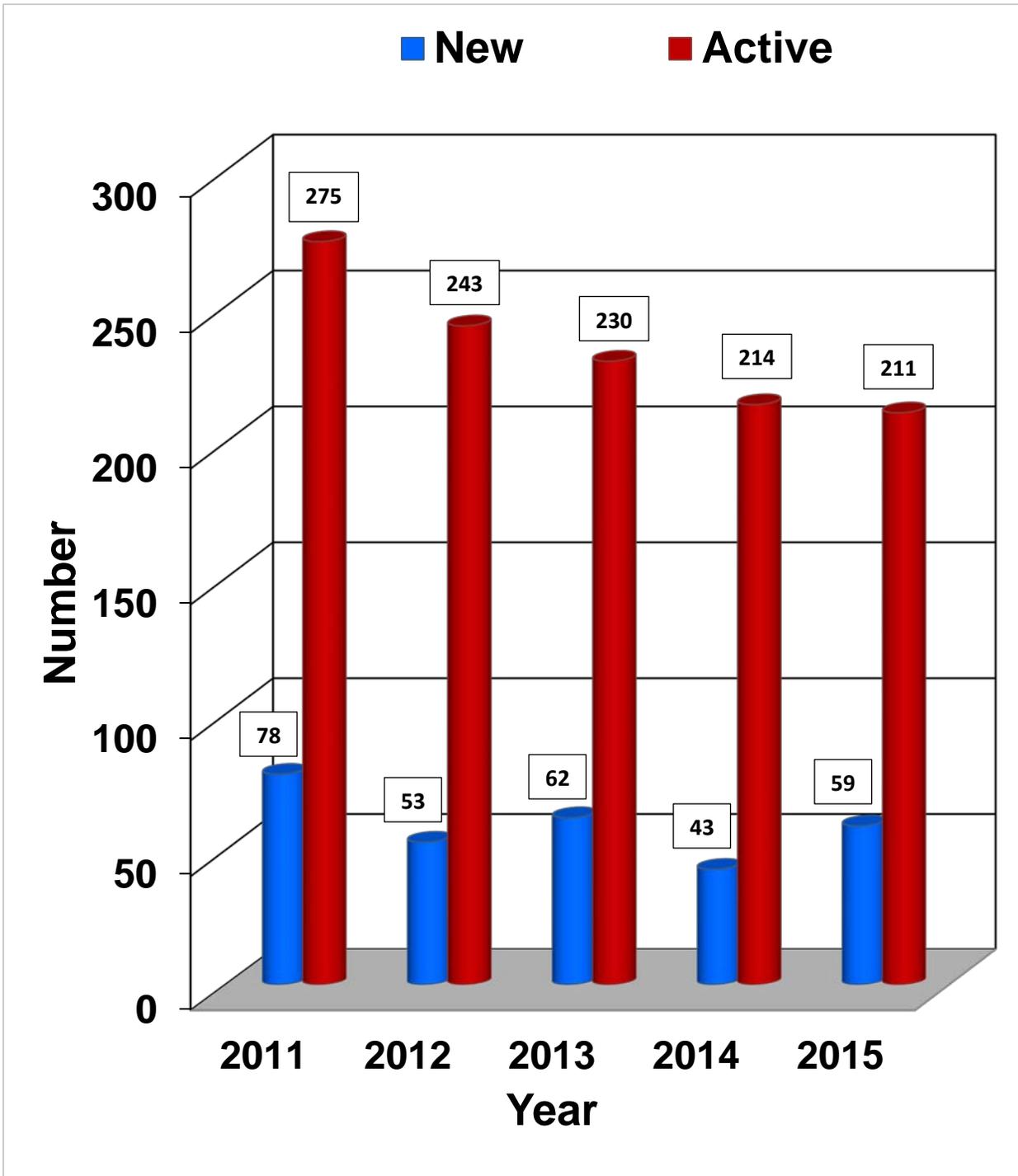
**Group:** ARS Office of Technology Transfer, University of Maryland Extension, and Montgomery County Department of Economic Development

**Name:** The High Tunnel Forum

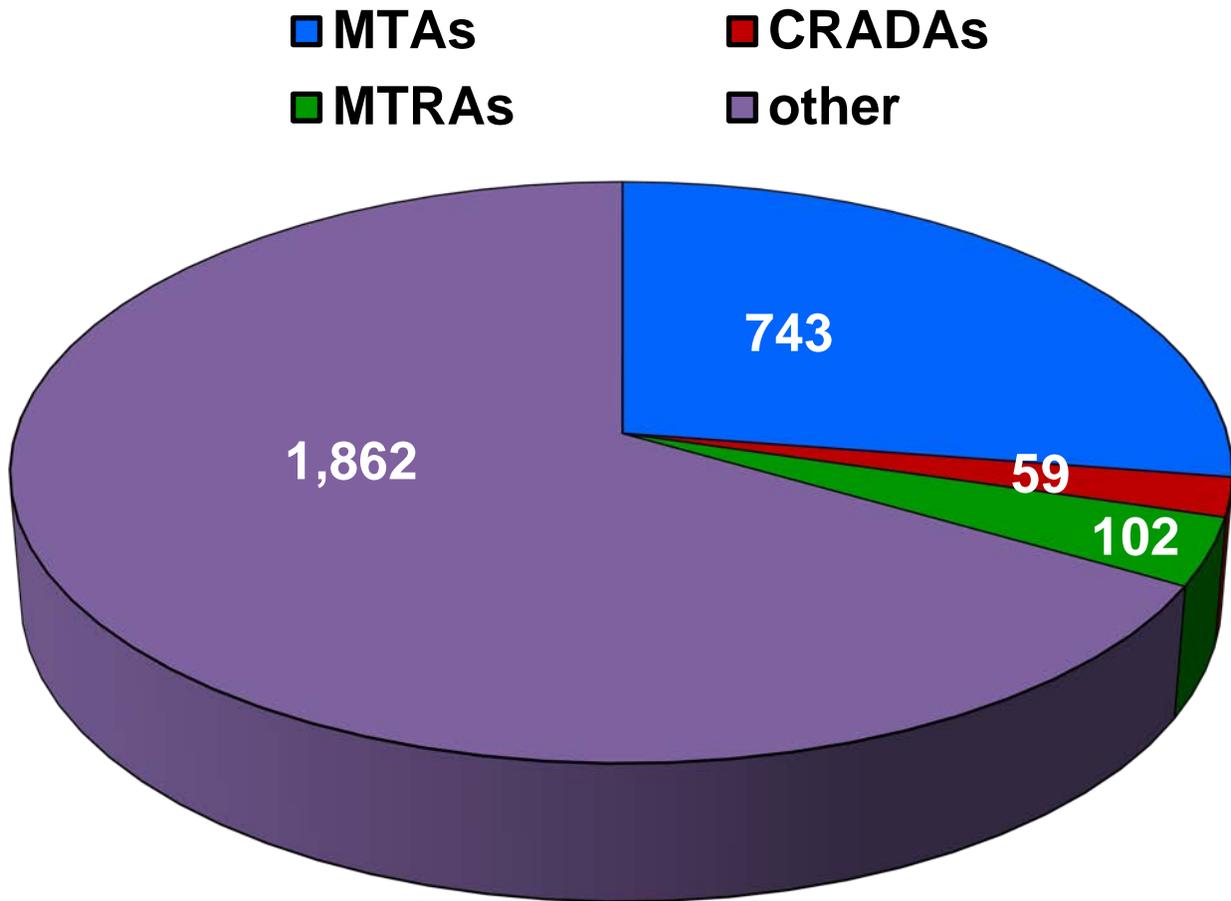
**Award:** Mid-Atlantic Region, Educational Institution and Federal Laboratory Partnership Award

3.12. Selected Metric Charts.

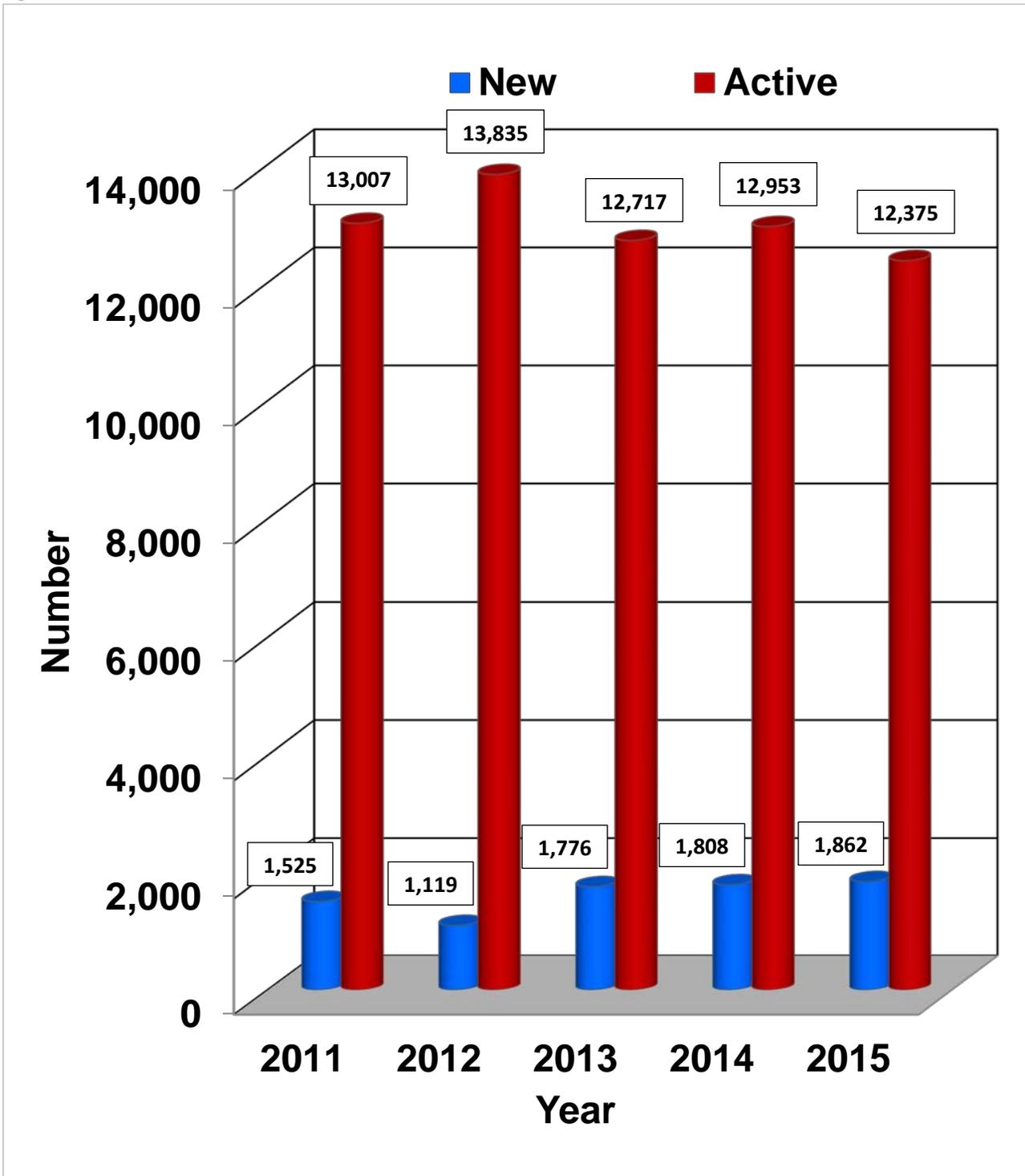
**Figure 1.** Number of new and active CRADAs. Part of the trend in the decreasing number of CRADAs may be due to the fact that we have a new mechanism (Material Transfer Research Agreement, MTRA) for collaborative research that was previous carried out under a CRADA.



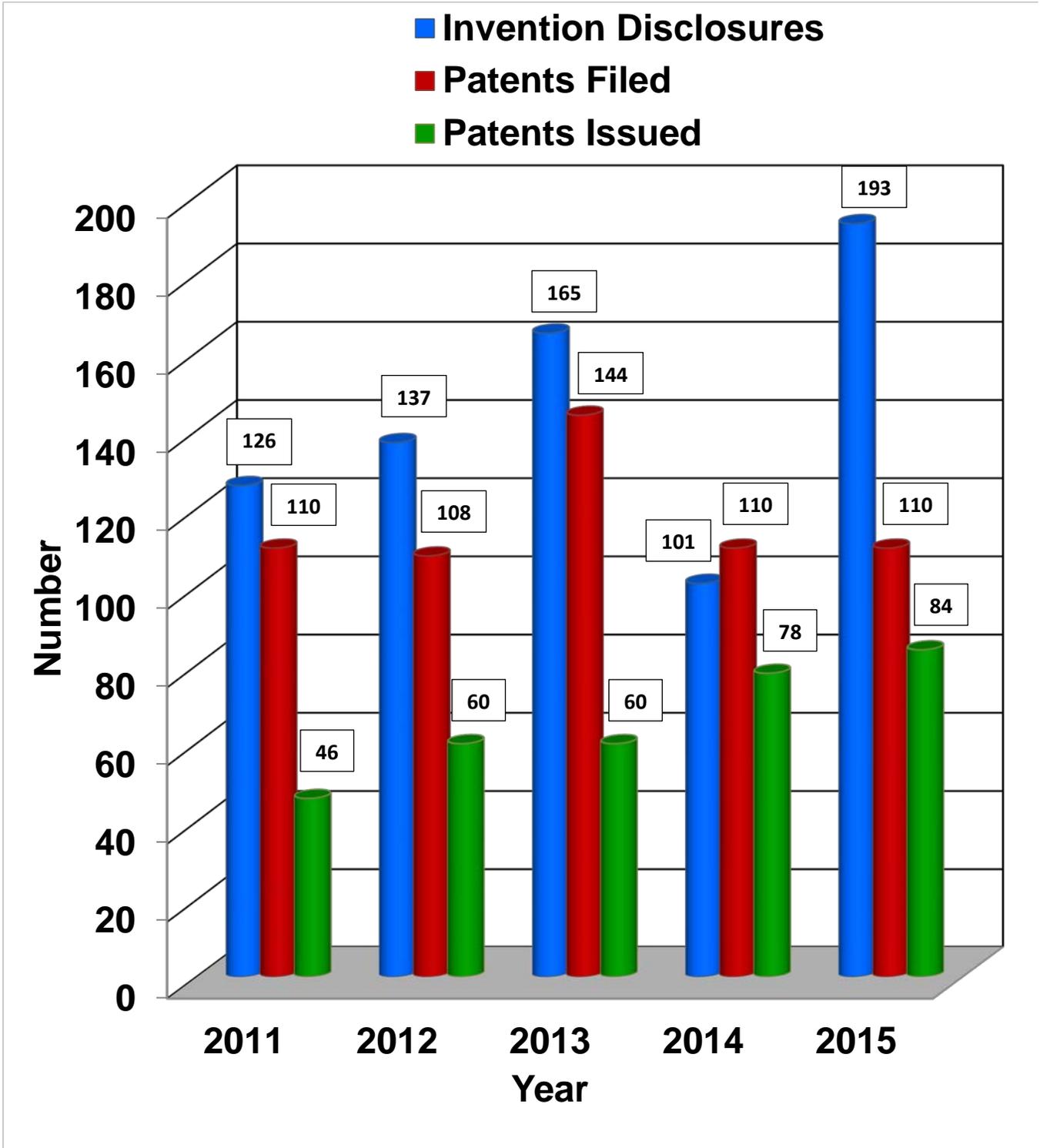
**Figure 2.** Number of collaborative research agreements executed by type in FY 2015.



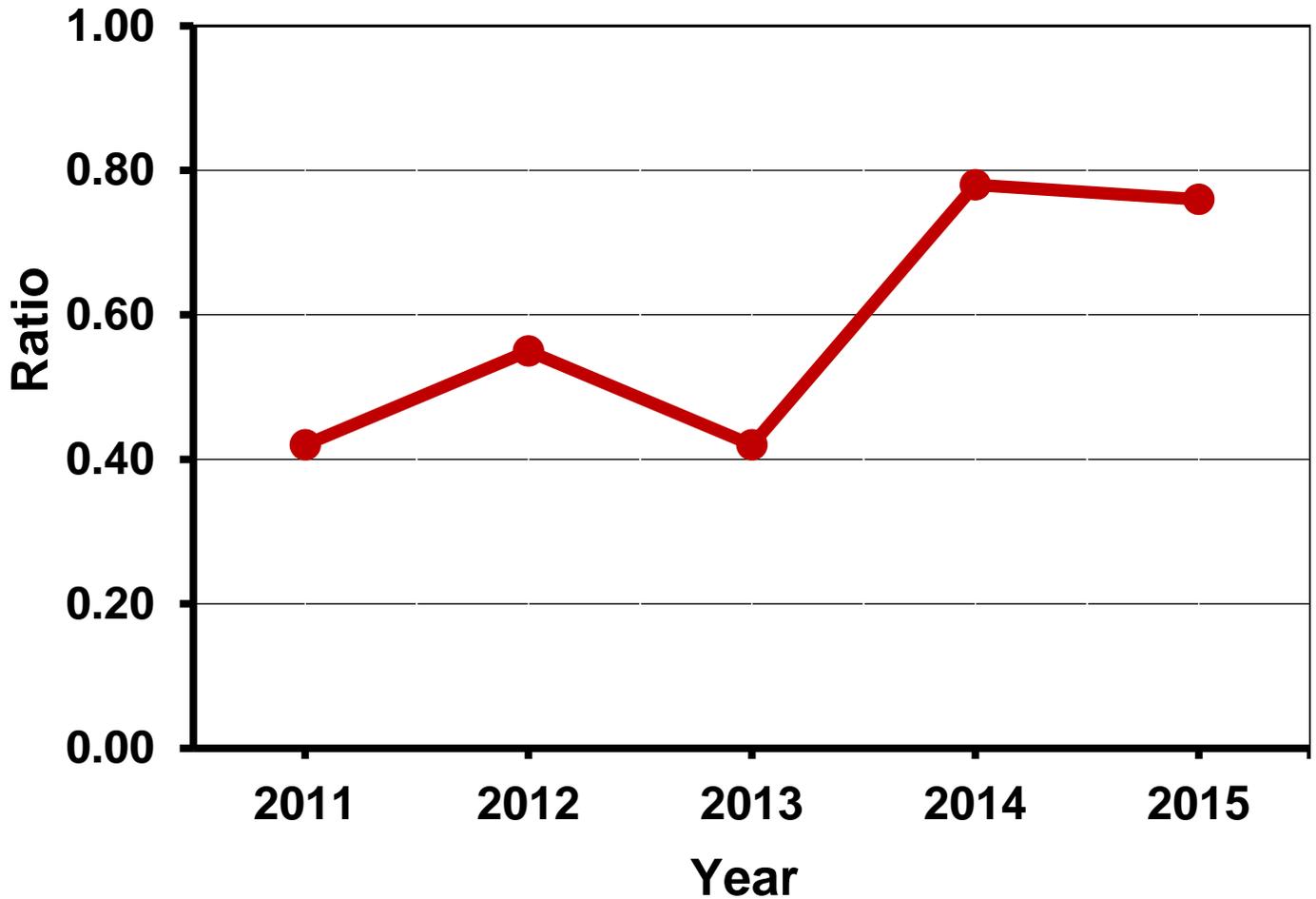
**Figure 3.** Number of new and active Trust Fund Cooperative Agreements, Reimbursable Agreements, Specific Cooperative Agreements and Non-Funded Cooperative Agreements.



**Figure 4.** Number of invention disclosures, patent applications filed and patents issued. The year in which a patent issues is not the year in which the patent is filed. The increase in the number of invention disclosure in FY2015 was the result of adding biological materials disclosures for the first time.

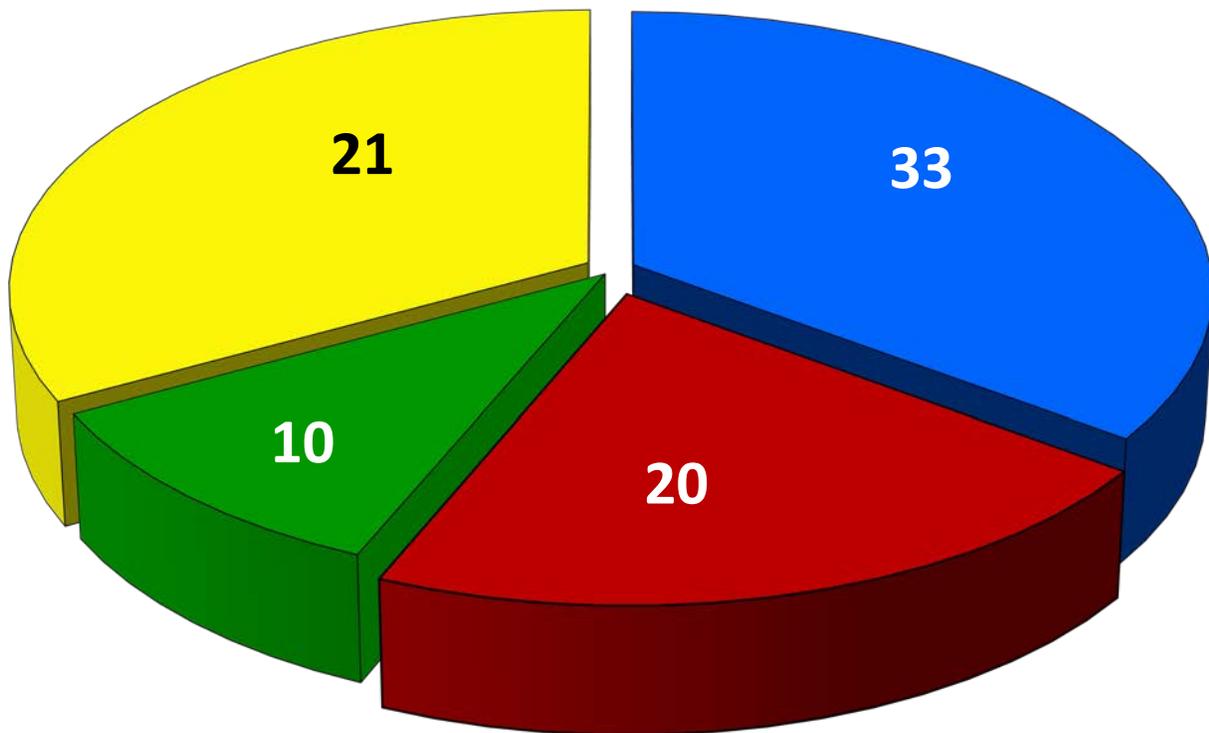


**Figure 5.** The ratio of patents issued over patent applications per year. While the year in which a patent issues is not the year in which the patent is filed, the ratio does represent a trend. The current goal is “judicious” patenting to increase the percentage of patents that are issued.

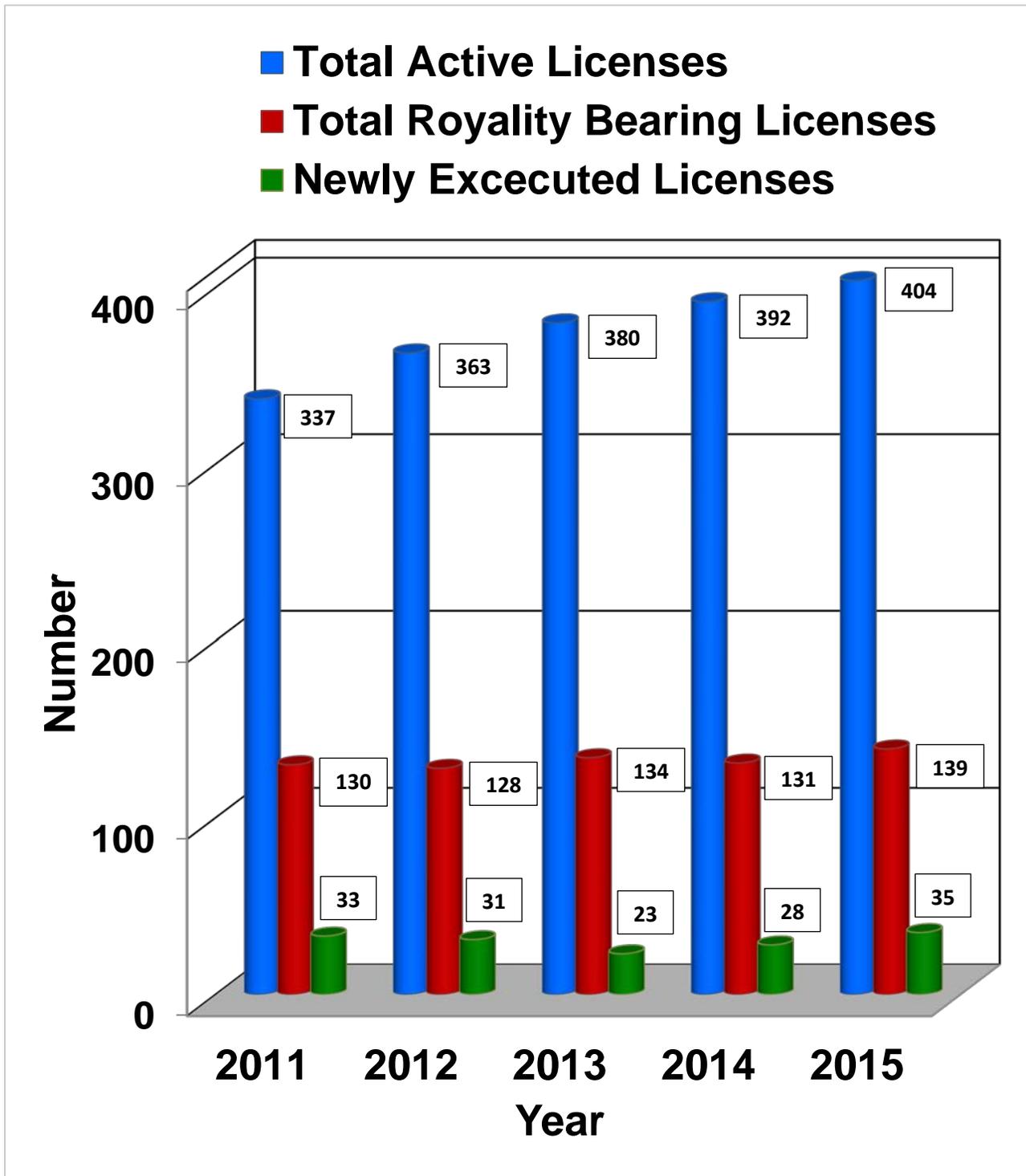


**Figure 6.** Number of patents issued in FY 2015 by scientific discipline.

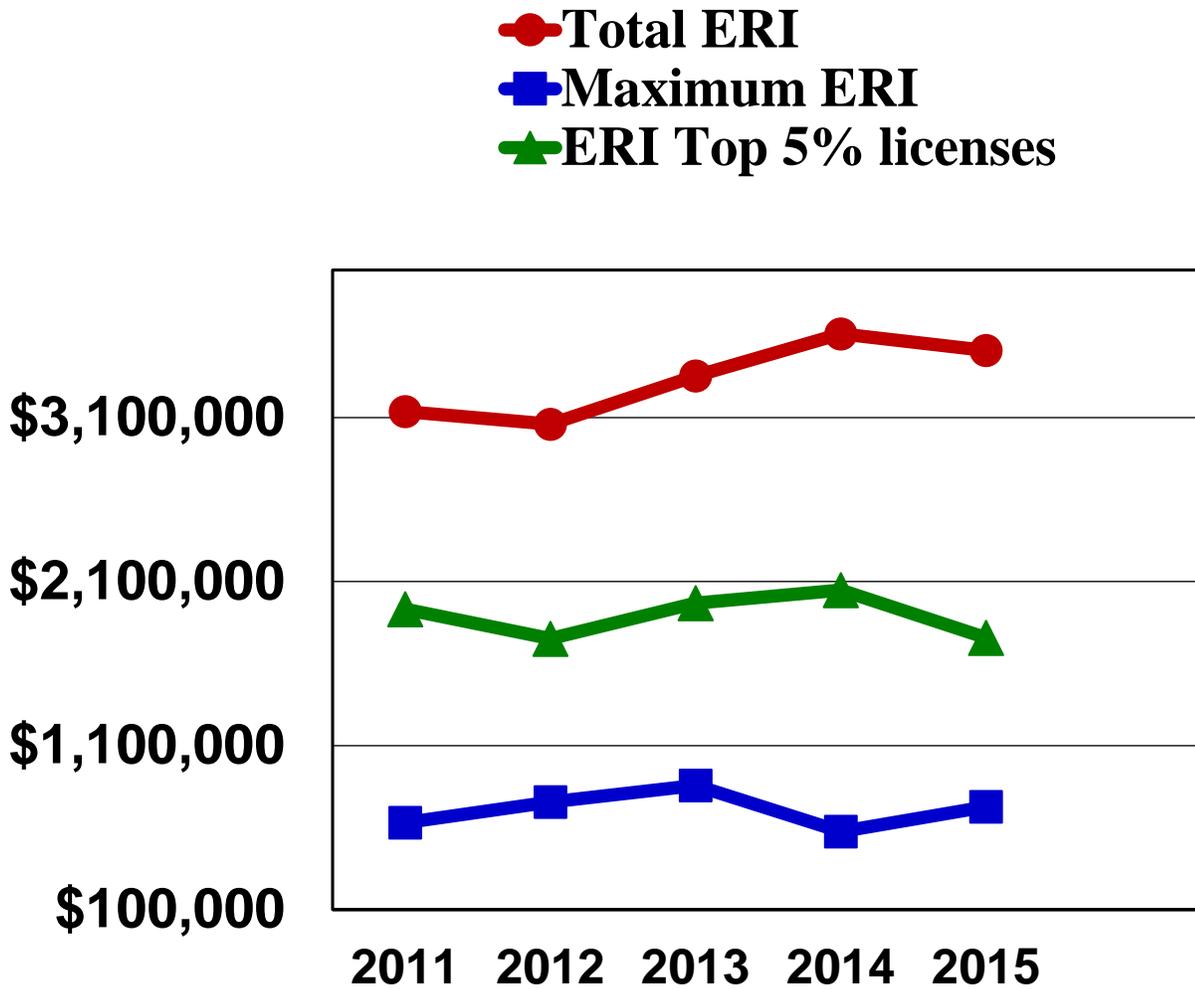
- **Life Science**
- **Chemical**
- **Mechanical & Measurements**
- **Plants**



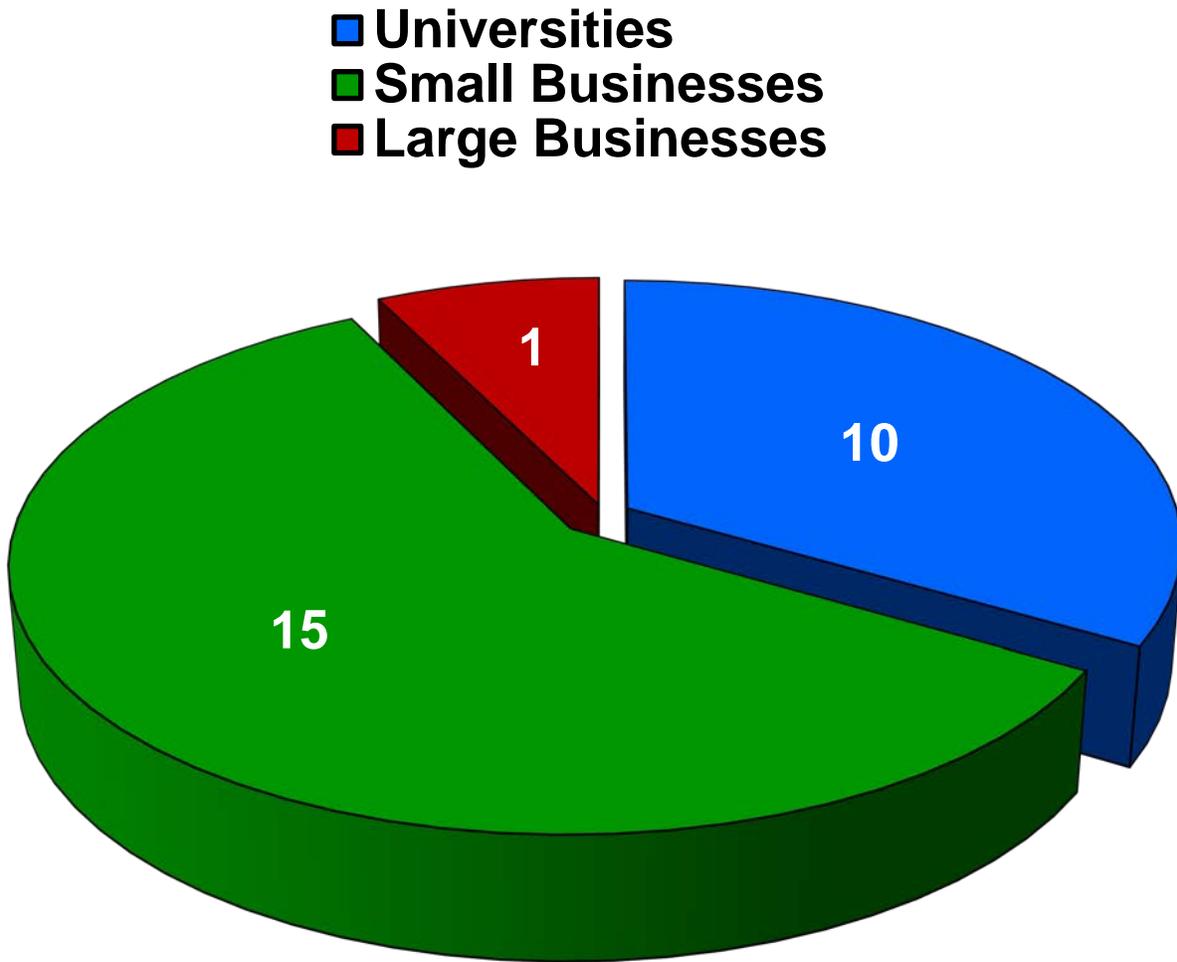
**Figure 7.** Number of license types per year.



**Figure 8.** Earned license royalty income (ERI) over time.



**Figure 9.** The number of new licenses executed in FY 2015 by business type.



**Figure 10.** Number of ARS-approved manuscripts per year.

